BRITISH VOLUME
Vol. 36-B, No. 3

AUGUST 1954

The Journal of Bone and Joint Surgery

Benjamin Collins Brodie

THE JOURNAL OF THE ENGLISH-SPEAKING WORLD

PUBLISHED JOINTLY IN LONDON, ENGLAND
AND BOSTON, UNITED STATES OF AMERICA

The Journal of Bone and Joint Surgery

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The Journal is published in ten annual numbers. The six American numbers are issued on January 1, April 1, June 1, July 1, October 1, and December 1; and the four British numbers are issued on February 16, May 16, August 16, and November 16. **The subscription price,** payable in advance, for the four British numbers alone, is £3 (10 dollars), or for the six American numbers alone, £4 (13 dollars). The combined subscription price for both British and American volumes is £6 (20 dollars).

The Journal is published in the United Kingdom for The British Editorial Society of Bone and Joint Surgery Limited by Messrs E. & S. Livingstone Ltd., 16–17 Teviot Place, Edinburgh; and 48 Bloomsbury Street, London, W.C. 1. British Editorial Offices: 82 Portland Place, London (Tel. Langham 1378). Editorial Secretary to the British Board: Miss Jean Barnes.

The Journal is published in the United States of America by The Journal of Bone and Joint Surgery, Incorporated. American Editorial Offices: 8 The Fenway, Boston, Massachusetts, U.S.A. Assistant Editor to the American Board: Miss Florence L. Daland.

THE JOURNAL

OF

BONE AND JOINT SURGERY

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PUBLISHED IN LONDON BY MESSRS E. & S. LIVINGSTONE LTD.

AMERICAN VOLUME PUBLISHED AT 8 THE FENWAY, BOSTON, MASS.

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THE JOURNAL
OF
BONE AND JOINT SURGERY

OFFICIAL PUBLICATION OF THE

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ANNOTATIONS

THE BLADDER IN TRAUMATIC PARAPLEGIA

The treatment of traumatic paraplegia has undergone many changes since the outbreak of the second world war, and although the problems which remain are still great there has been a marked improvement in results. That this is largely due to the work and influence of the special centres in which these patients have been collected brooks no denial. Workers trained in the original centres have carried their experience to others, and the knowledge that much can be done to improve the lot of the paraplegic and restore him to a useful life has stimulated interest in every aspect of his treatment.

The article by Hardy in this issue is concerned with the early treatment of the bladder; this is perhaps the most important aspect of the management of the patient as a whole. By a remarkable swing of the pendulum the method advocated is that of drainage by an indwelling urethral catheter, aided by bladder lavage. The indwelling urethral catheter was condemned by Thomson Walker in 1917 as a potent cause of infection, but was selected by Kidd in 1919 as the quickest and best method for use in paraplegia. Hardy mentions, only to discard, some of the other methods that have been used; here it may be apposite to note that it is not always the method which is at fault, but the manner of its use, and this applies especially to suprapubic catheterisation. If the catheter is small and inserted high so that it enters the bladder obliquely it has all the advantages of a urethral catheter without the disadvantage of causing urethritis (which occurred in 14 per cent of this series) and so initiating an ascending lymphatic infection. It is the formal low suprapubic cystostomy which results in delayed healing of the fistula and contraction of the bladder.

The good results and relative absence of infection in the fifty cases reported by Hardy were not due to the use of antibiotics or chemotherapeutic agents; these were not given routinely but were reserved for acute infections with constitutional disturbance, and eleven patients went through their in-patient treatment without them. To what then can we attribute the success of a method that had formerly given such bad results? There are many factors, each one having some bearing on the ultimate recovery of bladder function in so large a proportion of the patients. Firstly the early admission to the special centre; all were admitted within a few hours or days after injury, so that most had sterile urine at the outset. Secondly the early mobilisation of the patient, presumably made possible in more than half the cases by internal fixation of an unstable spine. Two-hourly rolling not only helps to protect the skin but also to prevent stasis in the bladder. Plaster fixation with its sequelae of pressure sores and limb contractures was avoided altogether. The early assumption of an upright posture aids drainage from the kidneys. Thirdly the type and size of the catheter used; Page (1952) drew attention to the irritant effect of the red rubber catheter in prostatic cases and the relative absence of urethritis with a latex catheter, and Adams (1953) pointed out the need for a small catheter which would allow the escape of urethral discharge. In Hardy's cases a Foley latex catheter of size not more than 18 French was used routinely. Its retention by a balloon dispensed with constrictive strapping around the penis. Fourthly the regular twice-daily clearance of bladder debris by a syringe of the Canny Ryall type. There is, as

always, the risk that to increase the number of manipulations increases the danger of sepsis, and bladder irrigation by a nurse or orderly, or even a doctor, is a potent source of infection. We prefer a modified syringe whose nozzle fits the funnel end of the catheter tightly; and a closed antiseptic system of drainage is better than an open bottle beneath the bed. Nevertheless the value of aspiration and irrigation outweighs its possible dangers.

But the most important item in the whole procedure is undoubtedly the aseptic handling of the catheter. Catheterisation is treated as a surgical operation and invested with the use of sterile gloves, gowns, towels and forceps with full aseptic ritual. The use of a screw clip during the period of manual control by the patient instead of a doubtfully sterile spigot inserted by unsterile fingers is another small but important point of procedure.

Trial periods without a catheter and instruction of the patient play their parts in encouraging his interest and co-operation but they are of less importance than the vital need for asepsis on the part of his attendants.

How far this method of treatment can be applied to battle casualties is difficult to determine, and this is a crucial aspect of the problem as it was in them that the indwelling catheter came to grief in both world wars. The wounded soldier may be less likely to have an unstable spine and so be less in need of orthopaedic treatment than the injured civilian, but he is more likely to have associated injuries necessitating other surgical operations, and there is further delay in his transportation to a special centre. Urethral catheterisation in unfavourable conditions is not always done with such meticulous attention to asepsis as is necessary for the paralysed bladder, and it is likely that early suprapubic catheterisation may still prove to be the best method when surgical surroundings are poor and delay in reaching a spinal injury centre is inevitable.

Hardy does not postulate the best time after injury at which the catheter should be passed; a delay of up to forty-eight hours will often show that a lesion is incomplete and avoid the need for any form of bladder drainage. Such a delay is not harmful and may save catheterisation by the less expert, and we feel that it should be advocated whatever form of bladder drainage is to be adopted finally. E. W. RICHES.

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SUDDEN PARAPLEGIA

Sudden paraplegia is one of the most dramatic and frightening of all the ills that can befall a man. Its possible causes are legion and, in the absence of a clearly defined injury, the differential diagnosis may be difficult or even impossible to resolve. Yet, if useful function is to be restored to the spinal cord, an immediate decision on treatment must be made.

Fortunately there is one simple test, lumbar puncture, which will distinguish between those needing medical treatment—for "transverse myelitis," disseminated sclerosis, avitaminosis, virus infection and the like—and those for whom immediate surgical intervention offers a ray of hope. In general terms it may be said that if a mechanical block exists in the cerebro-spinal fluid pathways (Queckenstedt's test) then the release of that block by the mechanical (or surgical) removal of the cause will give the spinal cord its only chance of recovery.

A word of warning about the performance of the lumbar puncture is necessary. One of the less uncommon causes of sudden paraplegia (in this instance arising within hours of the onset of the first sign of weakness) is extra-dural abscess. The abscess may be extensive and include the lumbar epidural space. While the needle is being introduced it behoves the operator to pause as soon as he feels the snap of the ligamentum flavum and to aspirate to see if pus is present. He may then avoid introducing infection into the leptomeninges.

It may also be impossible to enter the lumbar theca at one particular level because the compressing agent (e.g., a massive protrusion of a ruptured intervertebral disc) lies at that level. Or it may be impossible to withdraw cerebro-spinal fluid from the subarachnoid space because the theca is full of tumour (e.g., ependymoma) or of blood clot (e.g., massive subarachnoid bleeding from a ruptured vascular abnormality of the spinal cord).

Consideration of the history and of the neurological signs with particular reference to the upper level of sensory loss will usually enable the clinician to decide whether and where to operate; but, if there is any doubt concerning the site of the lesion, myelography by the cisternal route will establish the upper level of the block and so determine the site of election.

The case quoted by Clark in this issue vividly illustrates the sad fact that not all patients submitted to laminectomy will survive, nor will the operation necessarily allow the spinal cord to recover its function; but the attempt must be made at the earliest possible moment if any compression is present. Indeed Jefferson's dictum in the case of epidural abscess is that the time to operate is when the patient is complaining of root pain and of incipient weakness of the limbs and before he becomes paraplegic. From general principles, one would have expected that the most hopeful of all cases would be those in which a massive protrusion of a lumbar disc, compressing only the roots of the cauda equina, has been diagnosed and removed within twelve to twenty-four hours of its occurrence. Yet even these patients may take months or years to regain full sphincteric control.

Whatever the cause of the sudden paraplegia, the vital need to prevent complications must be borne in mind from the onset. From the moment the patient is first seen, a strict regime to prevent the onset of pressure sores in the anaesthetic areas must be enforced and scrupulous asepsis in the care of the urinary bladder ensured. Joint contractures should be prevented or minimised by regular physiotherapy.

Even if the course of events in the first few days makes it clear that the spinal cord is irreparably damaged or unlikely ever to recover useful function, the patient must be assisted to maintain a hopeful outlook. Early encouragement to move in bed, early assumption of mobility in a wheel chair, early acquisition of new skills of the hands and of the mind and early demonstrations of the vocations still open to a paraplegic patient will go far to mitigate his worst fears and enable him ultimately to live again a useful and possibly happy life.

A. Sutcliffe Kerr.

ASSESSMENT OF FUNCTION AFTER ARTHROPLASTY OF THE HIP*

MARGARET M. SHEPHERD, SUTTON COLDFIELD, ENGLAND

The development of materials that are tolerated by the body tissues and are suitable for the manufacture of plates, cups and prostheses has encouraged originality in reconstructive operations. This is particularly evident in arthroplasties of the hip. The British Orthopaedic Association thought it advisable to make a critical survey of the results of these operations, to assess their relative values in different conditions, and to enquire into the length of life of these reconstructed joints.

It was necessary to make a wide survey, to follow up a high percentage of the patients operated upon, to examine them critically, and to record accurately all the relevant facts. When all the information had been gathered, a method of assessing the results was needed.

Many reviews have been published of the results of operations on the hip. Some surgeons simply express a personal opinion of the results as " excellent," " good," or " poor," without defining the criteria for these verdicts. Recently Merle d'Aubigné (1952), Judet *et al.* (1951) and Judet and Judet (1952) have described systems for the assessment and comparison of hip function. These are based on a plan of allotting numbers from 0 to 6 to the various degrees of pain, movement, and the ability to walk; and adding these figures. Subtraction of the pre-operative from the post-operative figure gives an idea of the improvement, and is called the " amelioration rate." This method has two great advantages—simplicity, and the exclusion of personal opinion—but it is open to some criticism. The patient's own assessment is not included, and, though his appreciation may be limited by his lack of knowledge, and influenced by his own psychology, he is still in a unique position to form a judgment. Function as a whole is not given much weight. Activity in general (d'Aubigné) or ability to work (Judet) is considered in conjunction with pain; and walking is assessed separately. The habit of walking varies greatly in healthy individuals, and must do so to at least a similar extent in those with diseased hips. Ankylosis, or a small range of movement in one hip, is compatible with the ability to walk long distances without the aid of a stick. It seems that too much weight is attached to this performance when an arthroplasty is under consideration. For the calculation of the amelioration rate, pre-operative and post-operative examination and recording must conform to the same standards. It is difficult to achieve this. Finally, the reduction of such incongruous factors as the amount of pain, the degree of movement, and the ability to walk, to a single mathematical figure appears to me to result in over-simplification to the extent of unreliability.

Judet's *loc. cit* method was used in the analysis of 150 cases of cup arthroplasty. In general, the findings were consistent so far as the best and the poorest results were concerned; but the assessment of the remainder showed contradictions and was often at variance with the estimate of the result obtained directly from the examination of the patient.

CLINICAL MATERIAL AND METHODS OF ASSESSMENT

During this investigation for the British Orthopaedic Association the results of over 700 arthroplasty operations have been recorded and analysed. A method of assessment has been gradually evolved which seems to be reasonably reliable. I shall describe the method and then present various analyses showing it in use.

Clinical examination of the hip—Before discussing the assessment a few observations on the examination of the hip would not be out of place. The hip is not an easy joint to examine,

* A preliminary communication based on the work of the British Orthopaedic Association Research Group on arthroplasty of the hip.

and, apart from radiological measurements, absolute mathematical accuracy is impossible. Tilting of the pelvis and associated movements of the spine occur simultaneously with movements of the hip, especially when the movement of the hip has been restricted for some time. In measuring abduction and adduction, pelvic tilt can be allowed for by marking the positions of the anterior superior iliac spines at the end of the movement, and then using this line as the base from which to measure the angle for the range of movement. If the anterior part of the iliac crest has been removed a fair estimate can be made from the summit of the crests.

Flexion is more difficult to estimate with accuracy. The pelvis can rotate with very little appreciable movement of the iliac spines. If the opposite hip is ankylosed the range of flexion is most easily obtained, for the slightest pelvic tilt is reflected in the movement of the thigh on the side of the fixed joint. The most reliable method is to make evident the fixed flexion deformity, if any, by flattening the lumbar spine, and to measure the amount of flexion. Then the pelvis is fixed by full flexion of the opposite hip. The range of flexion from this position, calculated from the position of deformity, or the neutral position if there is no flexion deformity, is the true range. Even by this method error is still possible. If the patient forces his leg to the couch while the hip joint is fully flexed, the flexion movement may have added to it in some degree of extension. The best guide to the rotation of the hip joint in extension is the plane of the patella, and not the angle made by the foot.

Criteria for assessment of results—There are four criteria of a good result from a hip arthroplasty. The operation must result in a painless or almost painless hip, which has a useful range of controlled movement, and stability. It should allow the patient to be more active than before the operation, and the final result should be a hip which the patient is satisfied to have exchanged for the joint as it was before the operation.

Pain—The amount of pain suffered by an individual is difficult to estimate. It may be described under five headings. 1) There may be no pain—" none." 2) The patient may be conscious of pain at times, but it does not interfere with his activities—" ignores." 3) Activities are affected by the pain, but not seriously. Analgesics are taken fairly regularly—" makes concessions." 4) The pain interferes seriously with activities—" disabling." 5) The pain prevents many activities, including work—" crippling." It is true that one patient might ignore a pain whereas another patient might make concessions to a similar amount, but the effect of pain is subjective and is disabling, and important, to the extent that it affects the individual. When pain is associated largely with movement and weight bearing, the effect of pain on sleep is an unreliable standard.

Movements—The sum of the movements at the hip joint was expressed by Gade (1947) in one mathematical figure which allows comparisons to be made. This figure, the " mobility index," is calculated by deciding what constitutes the most important part of each separate movement—that is, the range which is of the greatest use in everyday life. For example, the first 15 degrees of abduction from a neutral position are much more valuable than a range from 15 to 30 degrees. A range greater than 30 degrees is of little use except to an acrobat. Again, 15 degrees of adduction has its uses, but adduction is less important than abduction. Taking this into account, Gade multiplied the different parts of the different movements by varying factors, thus weighting the important movements and the most valuable ranges of them (Fig. 1). He stressed that measurements of active movements were to be used. This is important. Great passive movement without control can be obtained by various operative procedures—for example, a Jones's pseudarthrosis. This may at times be what is required. One of the most satisfactory results in a severe case of ankylosing spondylitis was achieved when the patient was left with a completely ankylosed, and therefore reliable and painless, hip on one side and a flail Jones's pseudarthrosis on the other. Nevertheless if an arthroplasty is performed the aim of the operation is controlled movement. Therefore the calculation of active movement is required in an assessment of value.

In a normal adult hip Gade's calculation adds up to 100. An older patient may have excellent function with a mobility index around 55.

Functional activity—Active movement of the limb of the patient on the examining couch is of considerable importance, but the real value to the patient can be calculated only by the effect on his everyday activities. To obtain an estimate of this in a comparable form I have tried to express in one figure the function as shown by performance. Records of the ability of the patient to perform various ordinary activities before the operation and at the time of the examination are made (Table I). Black marks are allotted when an activity is impossible or difficult. Thus, as in the giving of golf handicaps, the greater the number of marks the worse the function. The Trendelenburg test has been included as an indication of stability, which is closely related to function.

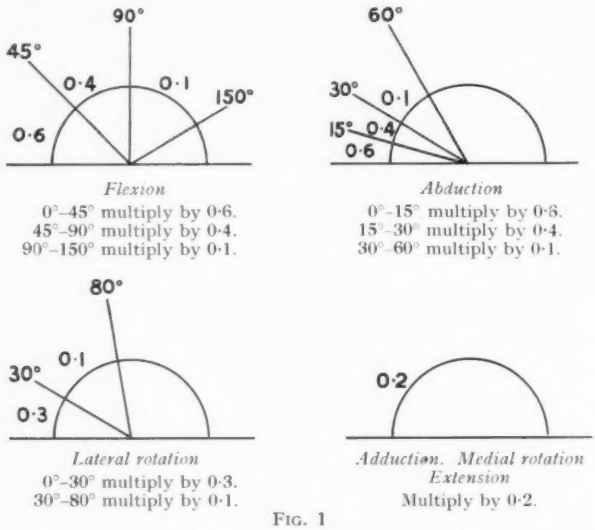

FIG. 1

Multiplication factors in Gade's calculation of mobility index.

These figures do not indicate any proportion of normal activity, and in themselves mean nothing, but they are comparable. The highest possible number of black marks, 28, indicates the worst functional result, a bedridden patient. It was found that a result of 13 or more black marks represented poor function. Such a patient's physical capacity not only prevents him from working and being a useful member of the community, but he needs the assistance of other people for his day-to-day existence. Up to 6 black marks is compatible with reasonably good function. A patient with 6 black marks could, for example, walk over a mile with a stick, although he limped without one, could not put on his own shoes and socks, and had difficulty in getting in and out of a bath. He could manage a sedentary job, and do some light gardening as a recreation.

Whether a patient is physically more active or not after the operation can be shown by a comparison of the black marks allotted for his pre-operative and post-operative performances.

The value of the patient's own assessment—The patient's own assessment of the value of an operation might be thought to be the most reliable estimate of its worth. In all summaries of results of operations in which the numbers of patients are given under the two headings "surgeon pleased" and "patient pleased" the patients are more often pleased than the surgeons. It is important in all surgical practice for the surgeon to inspire confidence, and when the patient's active co-operation is required, as in the post-operative treatment of an

arthroplasty, it is essential. A firm belief in the ability of the surgeon to improve his condition, together with a natural reluctance to admit that any ordeal endured has not been worth while, are largely responsible for the patient's optimism. The relief of pain, too, may mean so much to a patient that he is delighted with a result that has not achieved the aim for which the surgeon hoped and planned. Psychologically, the contrast between the pre-operative condition of advancing arthritis, when steady deterioration is visualised, and the post-operative state, in which improvement since the operation has occurred, makes further improvement

TABLE I

ASSESSMENT OF FUNCTIONAL ACTIVITY

Activity		Black marks
Limp	Yes	1
	No	0
Trendelenburg test	Positive	2
	Negative	0
Walking outside	Unaided	0
	Requires one stick	1
	Requires two sticks	3
	Requires two crutches	4
Distance walked	Not at all	4
	100 yards	3
	½ mile	2
	Over a mile	0
Completely bedridden		10
Putting on own shoe and sock	Yes	0
	With difficulty	1
	No	2
Stair climbing	Yes	0
	With difficulty	1
	No	3
Toilet	Yes	0
	With difficulty	1
	No	3
Bathing	Yes	0
	With difficulty	1
	No	3
Work and activities	Heavy physical	0
	Moderate	1
	Light	2
	Slight	3
	None	4

seem probable, and results in a much happier outlook. Many patients have used almost identical phrases in reply to the question, " Was the operation worth while ? " " Oh yes, at least now I'm improving, whereas before I was getting steadily worse "; or " My doctor said I'd have been bedridden by now if I hadn't had the operation."

Patients' answers to the above question might be divided into four groups. The enthusiastic " yes " was usually reliable. The " yes, but . . . " answer might mean anything. The answers expressing doubt, and the plain negatives were generally clear, and usually coincided with one's own assessment. The answers classified as enthusiastic were entertaining. " A thousand times, yes " is certainly definite. " Oh yes, I'm more versatile now " was from a patient who had had a previously ankylosed hip. "Oh, by Jove, I tell you" is hardly an

answer in ordinary English, but its meaning is clear. " I'd advise anyone to have it " is perhaps rather rash but it indicates the patient's satisfaction. "Oh, I'll say I've been resurrected," and " Thank God for Mr X " are also in this category.

One "yes, but . . ." answer came from a patient who limped in on two crutches. "Yes, I should think so, though I'll never walk on it again." Another answer was " Yes, it's a relief to be without the pain, but I'm more helpless now "; and again, " Yes, but after sitting I'm uncertain of myself, and I'm afraid to cross the street alone."

In one case in which an arthroplasty had failed and a later arthrodesis had been performed the patient was asked about the first operation. His reply is worth recording. " Yes, it was certainly worth while, because if I hadn't had it proved to me that it was not possible to get a movable joint, and I'd had this stiff one first, I'd have hankered after movement. As it is I'm quite content."

The answers expressing doubt varied. " Well, sometimes I think whether it was or it wasn't." Thirteen months post-operatively: " I think it will be when I get all right." After two years one patient was very cautious, saying " I'll wait and see," and another after the same period would not commit herself more than " I'm still hoping." The "Noes" were definite. " As far as I'm concerned it wasn't, honestly." " Don't ask me "; the tone of voice made this answer a definite negative. " No, I'm more of a crock now " does not leave one in any doubt, and neither does " I'd die rather than have it all over again."

A TABLE OF ASSESSMENT

In working out a Table of Assessment I have taken the following as the essential criteria of the results of operation: 1) pain; 2) active movement as shown by Gade's mobility index; 3) a comparison of ordinary activities before and after operation, as shown by the index of functional activity (the stability of the hip and the degree to which it can be relied on are reflected in this calculation); and 4) the patient's own assessment. The correlation of these factors cannot be a simple computation because the factors involved are not simple. The assessment table (Table II) seems complicated at first, but it is not difficult to use. It has been evolved during repeated comparisons of the records of the 700 arthroplasties. It does not depend on notes made before operation possibly by the surgeon, more probably a registrar, or even by a clinical assistant or house surgeon. Although the accuracy of records does not necessarily vary directly with the senoirity of the examiner, remarkable discrepancies do occur.

The grading for pain compares the pre-operative and post-operative conditions. It allows for the fact that a previously ankylosed, and therefore painless, hip may be converted into a mobile joint which is not then painless, but nevertheless represents an excellent result. The pre-operative index of mobility is ignored. Pre-operative records were not sufficiently standardised to permit a reliable calculation although, ideally, it should be included. The range of movement, however, affects the index of function by performance, and thus it is considered indirectly.

In using the Table the class of result is the lowest to which any of the factors brings the assessment. In practice, it was found that, generally, several factors agreed. If pain was disabling, function would be poor, and the patient's assessment either " doubtful " or " not worth while." In one type of case the mobility index alone lowers the grading. For example, if a patient can ignore his pain, can do a good deal more than he could before the operation, and is delighted with the result, but has a mobility index of 7, this is classified as a poor result. It is thought that in an arthroplasty operation where one of the aims is to achieve movement, a mobility index of 7, which represents perhaps 10 degrees of flexion and 5 degrees of medial rotation as the only movements at the hip joint, is not a good result. If the Table is to be used to assess benefit from hip operations in general, including arthrodesis, the mobility index would be excluded, and this would be reckoned an excellent result.

TABLE II

ASSESSMENT TABLE

	Pain	Mobility index	Function by performance	Patient's assessment
Excellent	" None " or " ignores "	50 or over	5 or under and decreased post-operatively by 3 or more or 6–10 and decreased by 5 or more	Enthusiastic "yes" or " Yes, but . . . "
Good	" None " or " ignores " or less than before operation	49–20	3 or under and decreased or 4–13 and decreased by 3 or more	Enthusiastic "yes" or " Yes, but . . . "
Fair	Less than, or the same as, before operation, but not " disabling " or " crippling "	19–10	4 or over and decreased only by 2 or 1 or as pre-operatively or increased by 1 * see note	Doubtful
Poor	" Makes concessions " and worse than before operation or " disabling " or " crippling "	Under 10	Increased by 2 or more	Not worth while

* If function by performance is over 24, or increased by 1, and pain is " concessions " or more, grade as " poor."

EXAMPLES OF THE USE OF THE TABLE

As examples, the gradings of Cases 8 and 6 in list 6 are as follows.

Case 8—The index of function by performance for Case 8 is given in full (Table III).

TABLE III

DETERMINATION OF FUNCTION BY PERFORMANCE IN CASE 8

Activity	Before operation	Black marks	After operation	Black marks
Limp	Yes	1	Yes	1
Trendelenburg	Positive	2	Positive	2
Walking—Aid	One stick	1	One stick	1
Distance	100 yards	3	Less than 100 yards	4
Shoes and socks	No	2	No	2
Stair climbing	With difficulty	1	With difficulty	1
Toilet	Yes	—	Yes	—
Bathing	With difficulty	1	No	3
Work and activities	A little dusting	3	A little dusting	3
Total		14		17

The complete grading is:
Pain—Ignores. Grading excellent or good.
Mobility index—35. Grading now good.
Function by performance—As above, worsened by 3. Grading now poor.
Patient's assessment—" Not worth while, I'm more of a crock now." Grading poor.

Thus the final grading is **poor.** Impaired function, and doubt or dissatisfaction in the patient's mind as to the value of the result are often, as in this case, associated with instability of the joint and a feeling of insecurity.

Case 6—The following was the method of grading.
Pain—Ignores; was disabling before operation. Grading excellent or good.
Mobility index—52. Grading excellent
Function by performance—Before operation 11 black marks; after operation 4 black marks (decreased by 7). Grading excellent.
Patient's assessment—" Definitely worth while." Grading excellent or good.

Thus the final grading was **excellent.**

ANALYSIS OF THE PRACTICAL APPLICATION OF THE METHOD

To test the accuracy of the method of assessment all the cases examined in the review were classified according to the Table. Seven lists from separate surgical centres were available. The first five of these taken together showed a follow-up of 85 per cent of all the cases operated upon during the period under consideration. The other two lists were statistically incomplete but are nevertheless interesting (Table IV).

TABLE IV

CLASSIFICATION OF GRADING OBTAINED IN THE SERIES UNDER REVIEW

Grading	List 1 (per cent)	List 2 (per cent)	List 3 (per cent)	List 4 (per cent)	List 5 (per cent)	List 6 (per cent)	List 7 (per cent)
Excellent	15	13	14	11	14	17	10
Good	25	21	26	24	24	33	21
Fair	28	38	26	28	33	28	29
Poor	31	28	34	37	29	22	40

TABLE V

CONDITIONS FOR WHICH ARTHROPLASTY WAS PERFORMED AT SEVEN SURGICAL CENTRES
(in percentages of all cases in each list)

	List 1	List 2	List 3	List 4	List 5	List 6	List 7
Osteoarthritis	78	49	60	78	64	79	67
Fracture or dislocation	5	—	11	4	5	3	14
Congenital subluxation	8	12	13	1	5	6	11
Otto pelvis	2	1	1	3	3	—	1·5
Congenital dislocation of the hip	3	10	4	0·5	3	3	1·5
Infective arthritis	—	7	8	1	1	4	1·5
Rheumatoid arthritis	3	5	1	8	5	1	—
Ankylosing spondylitis	—	15	1	6	14	3	1·5

Two things are striking about these figures. One is the similarity of the results in the different lists. I shall suggest reasons for the discrepancies later. The other striking fact is the high percentage of the results graded as poor. The standard I took is not unduly high, but the method of grading cannot take into account the effect that age has on a group of patients who are far from young at the time of operation. It is not to be expected that a patient who has an operation at the age of sixty-eight can be in very much better form physically five years later. Again, some of the patients have a progressive disease such as rheumatoid arthritis, or some geriatric condition has overtaken them. No classification can, in the first analysis, allow for these factors, but they could be taken into account at a later breakdown. I would like to stress that a poor result is one that has failed to achieve the standards

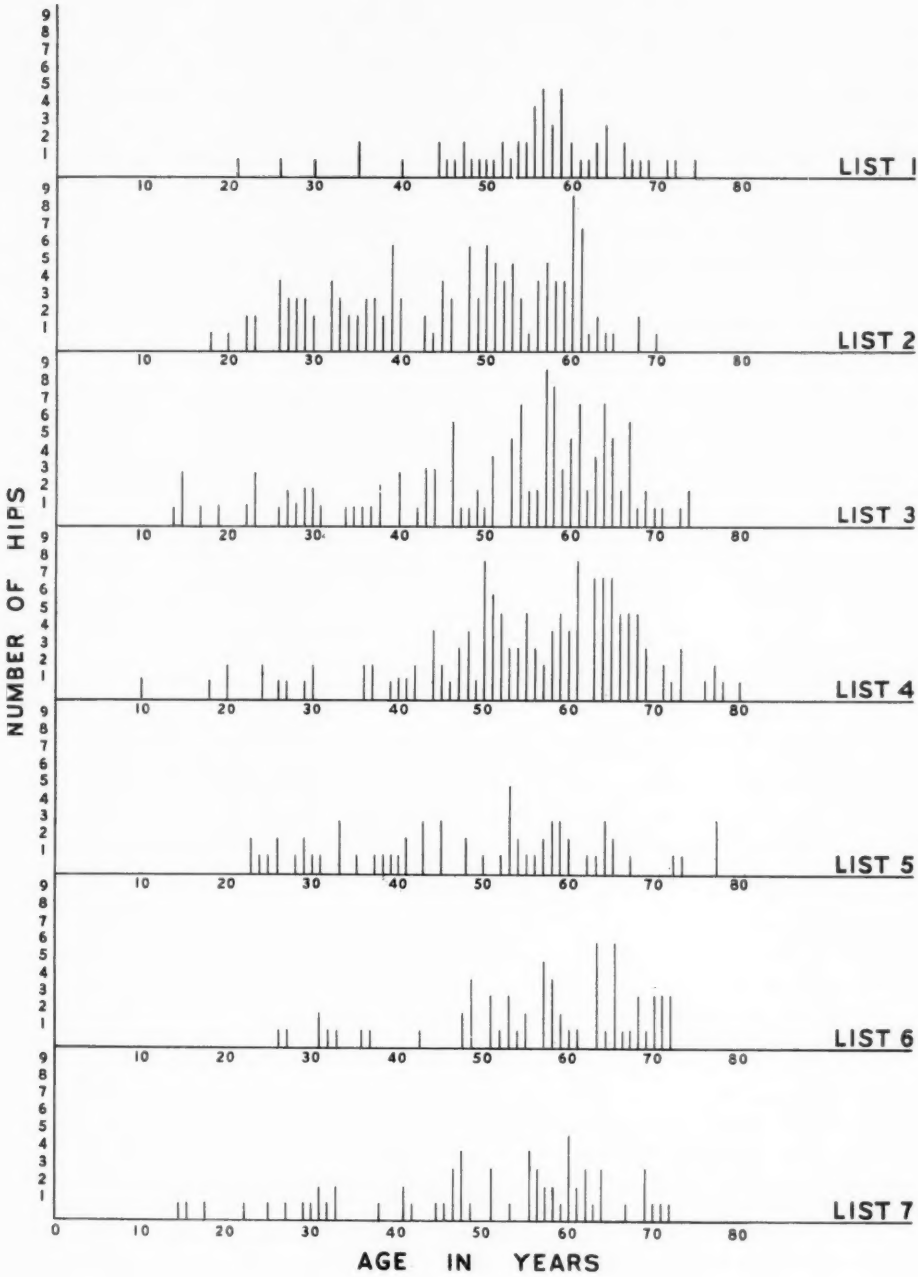

FIG. 2
Age at time of operation.

considered satisfactory for an arthroplasty operation. Humanly speaking it may have been well worth while. Here is an extreme illustration of this. A young woman, who as a child had had infective arthritis resulting in bilateral ankylosis of the hips, had a double hip arthroplasty performed. Two years later both hips had again fused in slight adduction. From an orthopaedic standpoint this can only be called a poor result. However, before the post-operative ankylosis had occurred she had an illegitimate child, with which both she and her mother were delighted.

The graded lists should be studied in conjunction with the following analyses (Table V and Figs. 2 and 3). These show the various diagnoses, the ages of the patients, and the time which has elapsed since operation.

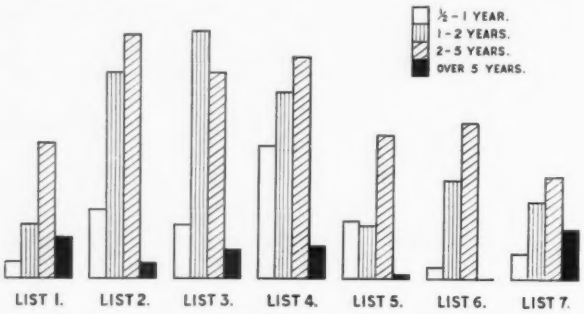

FIG. 3

Interval between operation and assessment of result.

It will be seen from Table IV that List 6 has the highest percentage of excellent and good results, and the lowest percentage graded as poor. List 6 is composed of private patients. The diagnoses are spread over most of the conditions for which arthroplasties are performed. Ages range from twenty-six to seventy-four at the time of the operation. In no case seen had five years elapsed since operation. The class of patient, and the fact that all operations done were under five years, might account for the better than average grading.

List 2 has the highest percentage of results graded as fair. Here the highest number of bilateral operations has been done—25 per cent of the cases—and also the list shows the highest proportion of cases of ankylosing spondylitis. Many bilateral operations are done for congenital dislocation of the hip. In severe cases of this condition, and also in cases of ankylosing spondylitis, a fair result is all that can be expected, and is regarded as satisfactory. This seems to explain the larger group here.

List 7 has the highest proportion of poor results. It has, in fact, by far the greatest number of cases followed up for more than five years. If these are excluded the percentage of poor results falls from 40 per cent to 36 per cent. The average proportion of poor results for all the lists is 31 per cent. If List 6, which contains no case followed up for 5 years, is excluded the average proportion of poor results for the other six lists is 33 per cent.

List 4 has a slightly more than the average proportion of poor results. Here we have the biggest age span—ten to eighty years—and the highest percentage of cases of rheumatoid arthritis. Lists 4 and 1 are the most fully investigated lists from the statistical point of view, 96 per cent of the patients having been seen. Patients who could not come up to hospital were visited in their own homes; they had, on the whole, less satisfactory results than those who came to the hospital.

The suggested explanation of the small discrepancies in the type of result are not proved facts, and many factors obviously influence the result. Taking all this into account, however, it does appear that the method of assessment is reasonably reliable. Further analyses are at present in progress, and their consistency confirms this.

DISCUSSION

Is an accurate method of assessment of any value? I think it is. A recently published survey on femoral head prostheses by the committee on scientific investigation of the American Academy of Orthopaedic Surgeons quotes figures from 587 surgeons who answered a questionnaire. The total number of prostheses of all types that had been used was 5,082. Eighteen types had been listed under names—Judet, McBride, etc.—and nineteen other types were mentioned, making thirty-seven in all. The average time since operation in this preliminary survey was 10·3 months, and rightly no assessment of results has been attempted. John Stuart Mill wrote: "All good things which exist are the fruits of originality." This may be true, but the converse is not. Originality in thought is wholly admirable; translation into use in surgery not necessarily so. Discrimination is essential.

A surgeon in his own work must rely to some extent on impressions, and when deciding on the type of operation to be performed in a certain case, he must take into account his own preference. This preference may be founded on many factors, including his own experience, his feeling of rightness and suitability in a particular case, and even hero worship for a teacher, as well as a scientific knowledge of facts. But when he reads a paper to increase this knowledge, it is important that it should convey more precise scientific truth. This depends not only on clinical observation and careful recording but on statistical accuracy, when "description gives place to measurement, and calculation replaces debate." These measurements and calculations should be available for a surgeon to help him to assess methods of treatment, and to discriminate amongst them. An impersonal method of assessment that is comprehensive, generally applicable, and reliable, is essential. It has been my endeavour to devise and present such a method.

I wish to acknowledge with thanks the help I have received from Mr T. E. Cowan, statistician to the Middlesex Hospital. We are much indebted to the Nuffield Foundation for their grant from the Oliver Bird Fund, which has made this work possible.

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APPROACH TO THE HIP

A Suggested Improvement on Kocher's Method

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This paper describes a method of preserving the integrity of the gluteus medius muscle during the posterior approach to the hip joint. The present considerable interest in this approach is largely due to Gibson's admirable description in 1950 of Kocher's incision, and also, rather coincidentally, to the general increased interest in arthroplasty of the hip. While the anterior Hueter incision is recommended by the Judet brothers, many surgeons find that more work can be carried out with the more ample exposure of the posterior route. The very mobility imparted by arthroplasty, however, demands preservation of gluteal power to a degree little short of normal—certainly to a degree not always provided by the Kocher and Gibson approaches, because transverse division of the gluteus medius or its trochanteric insertion does not always result in satisfactory abductor power, even after strong suture or bony fixation. It was with the purpose of preserving the total continuity of the muscle that the method here described was evolved.

ANATOMY

The procedure depends on the anatomical observation that the gluteus medius and vastus lateralis can be regarded as being in direct functional continuity through the thick " tendinous " periosteum covering the greater trochanter. Moreover, these two muscles meet at an angle, open anteriorly, so that by loosening the periosteum from the trochanter it is possible to displace forward the combined muscle bellies like a bucket handle. In practice, the periosteum may not always strip easily from the trochanter, and in order to preserve intact the tendinous junction it may be convenient to shave the bony surface of the trochanter so that a few thin flakes of bone adhere to the tendon.

DETAILS OF TECHNIQUE

The approach is essentially lateral and gives a view of the anterior, posterior and superior aspects of the hip joint. The skin incision (Fig. 1) is mid-lateral, centred over the greater trochanter, the tendinous junction of the gluteus maximus and tensor fasciae latae above, and the middle of the shaft of the femur below: its length depends on the amount of subcutaneous fat. The gluteal fascia and ilio-tibial band are exposed and divided in the straight mid-lateral line along the whole length of the skin incision (Fig. 2). The gluteus maximus is retracted posteriorly, and the tensor fasciae latae anteriorly. The gluteus medius is exposed and by blunt dissection is separated from the pyriformis and gluteus minimus deeply. The posterior border of the gluteus medius is clearly defined, and the point at which it joins the prominent posterior edge of the greater trochanter is identified. From this point an incision down to bone is made through the periosteum and tendinous fascia obliquely downwards, across the trochanter to the middle of the lateral aspect of the femur, and is continued downwards in the vastus lateralis to the lower limit of the original incision (Fig. 3). The attachment of gluteus medius to the trochanter, and the periosteum and the tendinous junction of medius and lateralis, and the origin of lateralis are then peeled off the bone in one piece. This must be done with a scalpel or with a sharp chisel: it is not usually possible to do

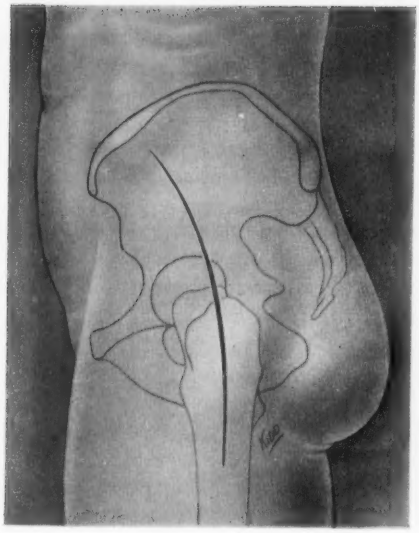

FIG. 1

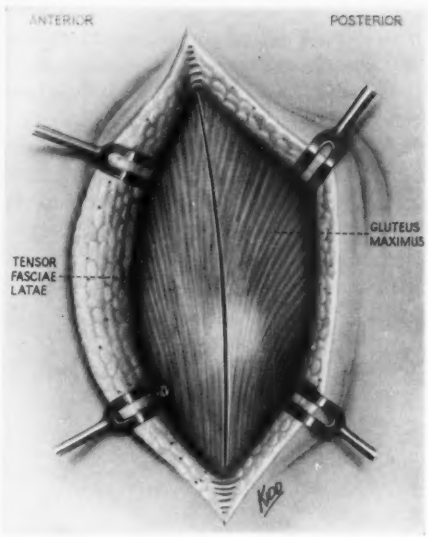

FIG. 2

Figure 1—Skin incision. Figure 2—Incision of fascia lata between tensor fasciae latae in front and gluteus maximus behind.

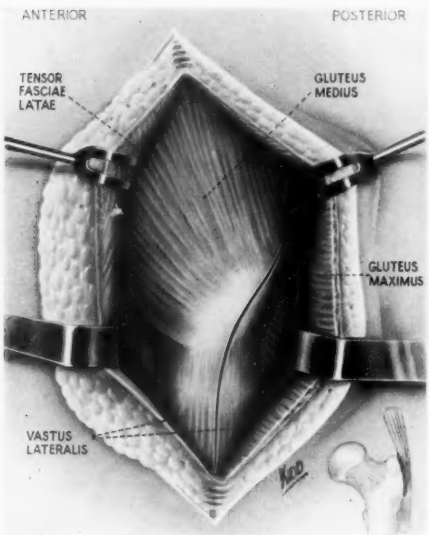

FIG. 3

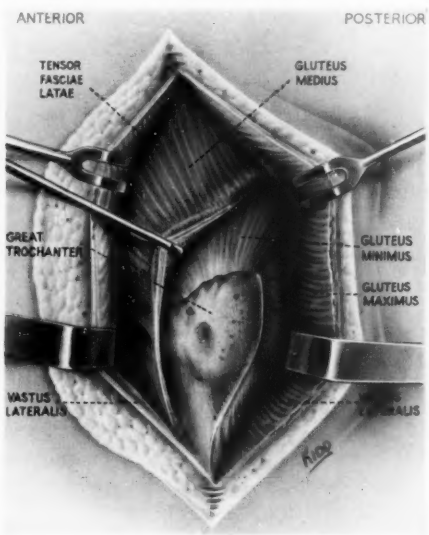

FIG. 4

Figure 3—Incision at posterior margin of gluteus medius and vastus lateralis, showing line at which loosening of periosteum of trochanter commences. Figure 4—Anterior displacement of gluteus medius and vastus lateralis in continuity.

it satisfactorily with a raspatory. The portion of the vastus lateralis which is peeled off in this way includes, of course, that attached to the upper part of the linea aspera, the inferior border of the greater trochanter and part of the shaft of the femur. The whole combined muscle mass—gluteus medius and vastus lateralis with their tendinous junction—is then displaced forwards (Fig. 4). There is no difficulty in doing this, though it may be necessary to detach a small part of the vastus lateralis arising from the intertrochanteric line, and also to divide any anterior attachment that gluteus medius may have to minimus. The rest of the operation is similar to any other lateral or postero-lateral approach; the tendon of gluteus minimus is split and divided (Fig. 5) and retracted upwards to expose the capsule of the hip joint (Fig. 6).

At two points bleeding may occur—one from the ascending branch of the medial circumflex artery behind the greater trochanter and the other from the transverse branch of the lateral femoral circumflex artery deep to the vastus lateralis, but neither is troublesome.

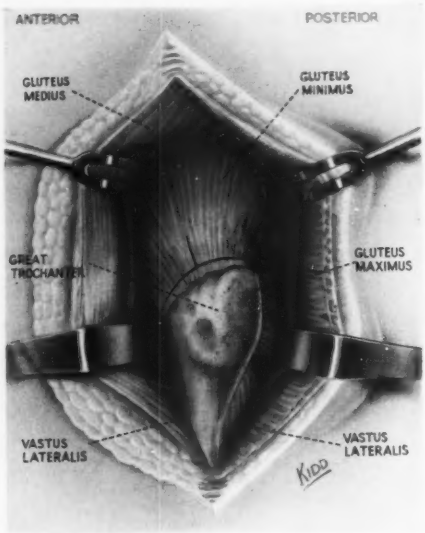

FIG. 5

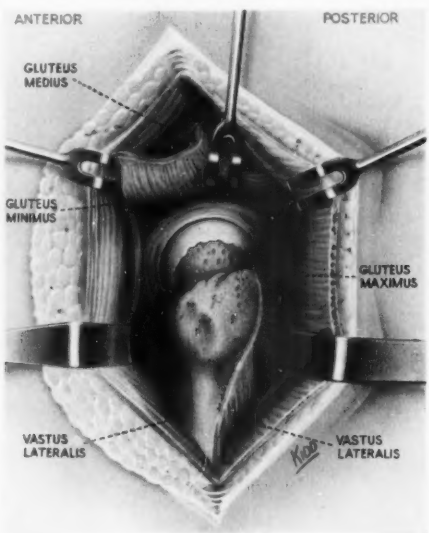

FIG. 6

Figure 5—Gluteus minimus revealed with line for division of its tendon. Figure 6—Hip joint revealed with neck and upper shaft of femur.

After finishing work on the hip joint, closure is carried out in layers. It is usual to suture the gluteus minimus and the capsule in one; the gluteus medius and vastus lateralis are returned to their original position and the tendinous part is sutured to the undisturbed part of vastus lateralis, to the deep insertion of gluteus maximus and to the upper part of the quadratus femoris. This point in the procedure is facilitated by having the leg abducted so that the tension on gluteus medius is reduced. About three strong sutures are necessary and chromic catgut is used.

DISCUSSION

Approaches to the hip joint fall, in principle, into two main groups. 1) Operations which approach the joint in front of, or behind, an intact gluteus medius (Hueter's and Langenbeck's incisions respectively). Access, however, is not easy and depends on very experienced

retraction and " positioning " of the limb, and even then the view of the hip joint is somewhat restricted. 2) Operations in which the continuity of the gluteus medius is divided either by detaching part of its origin (Sprengl, Smith-Petersen), or by division of its insertion through the tendon or through the trochanter (Kocher, Murphy, Ollier, Brackett). Many surgeons prefer the wider and more ample exposure of this latter method. It is doubtful, however, whether a severed gluteus medius can subsequently be as strong as an undivided muscle, and the diversity of methods of reattaching the trochanteric insertion suggests the uncertainty of efficient union.

We believe that the manoeuvre of displacing gluteus medius introduces a third principle of approaching the hip joint in that the muscle, while still intact, is turned aside, and not divided either at its origin or insertion. Continuity is not interrupted and early restoration of abduction power has been secured.

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EARLY TREATMENT OF THE BLADDER IN TRAUMATIC PARAPLEGIA

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Disordered bladder function in traumatic paraplegia is only one of the many problems presented by such patients and successful treatment of this one aspect cannot be achieved by even the most meticulous management of the urinary tract without successful treatment of the patient as a whole. All the problems of traumatic paraplegia such as are concerned with the orthopaedic lesion—the bladder, the bowels, the skin, the circulation or the muscles—are inter-related and each is as much dependent on the whole as the whole is dependent on each integral part. Sores, sepsis, muscle spasms, prolonged recumbency and immobility all produce profound structural and functional changes in the urinary tract and, because of this, great care must be taken to avoid the development of complications in one system while special attention is being given to the treatment of another.

For this paper analysis has been made of the first fifty patients with paraplegia who were admitted to the unit over a period of four years. All were admitted within a few hours or days from the time of injury and they all had the same régime of general treatment as well as the same method of bladder management. They include eleven cervical, six thoracic, twenty-five thoraco-lumbar and eight lumbar spinal injuries.*

MANAGEMENT OF THE PATIENT AS A WHOLE

Orthopaedic measures—Specific orthopaedic measures were used on twenty-eight occasions and, except in two cases of cervical injury in which skull traction was employed, the operative procedure was one of open reduction and internal fixation (Holdsworth and Hardy 1953). No patient was immobilised in plaster.

Nursing—All the patients were nursed on ordinary mattresses on spinal beds. The natural curves were supported by pillows and initially each patient was rolled in bed at two-hourly intervals throughout the day and night. This time interval was increased after some weeks and lengthened according to the reactions observed in the skin and subcutaneous tissues.

From the fourth week onwards the upper half of the spinal bed was racked up for several periods each day, and mobilisation to the chair stage was attained after a further four to eight weeks according to individual circumstances.

Skin—The skin over the bony prominences in the paralysed areas was massaged with soap and water, dried and powdered at least once each day. All areas could be observed at all times of the routine two-hourly turns.

Diet—The normal diet was supplemented by extra protein in the form of cheese and meat. A liberal fluid intake of between six and eight pints daily was encouraged and easily maintained by most patients.

Bowel control—Inopportune incontinence and soiled linen were reduced to a minimum by the regular use of laxatives, aperients, enemas and manual evacuation of the rectum either singly or in combination according to the return of reflex or other activity in the lower bowel.

Physiotherapy—Early active and passive physiotherapy included spring expander exercises for the upper limbs and passive movements of the lower. These were done several times daily.

Therapeutics—All patients were given iron in the form of ferrous sulphate three times a day and vitamins B and C. No antibiotics or chemotherapeutic agents were given as a routine, and eleven patients went right through their period of in-patient treatment without the use of penicillin, chloromycetin or other antibiotics.

General mobilisation—After the first few weeks the general activity of the patients was increased. They were encouraged to ease themselves in bed, to assist in their routine turnings

* The injuries described as thoracic and lumbar do not include those involving both the twelfth thoracic and first lumbar vertebrae, which are here called thoraco-lumbar.

and all nursing procedures, so that by the time they were ready for the chair stage they were in a confident and reasonable state of physical fitness.

MANAGEMENT OF THE BLADDER

With this outline of the general treatment in the background the management of the bladder can be dealt with more specifically. After spinal cord injury no organ can be more fickle and temperamental in its efforts at readjustment. In the first instance there is a phase of inactivity which may last from hours to many months. Then there is a phase of increasing reflex activity, when for long periods the reflex muscle contractions are of insufficient strength or duration to produce efficient emptying and the co-ordination of detrusor action and sphincter relaxation is very imperfect.

Co-ordinated reflex activity depends for its existence on an intact sacral cord. Its appearance or non-appearance can be predicted in some measure by the presence or absence of other reflexes using the same sacral segmental pathways, such as the bulbo-cavernosus and anal skin reflexes and the ankle jerks. It can be observed in the first feeble efforts of urine voiding and recorded in part by cystometry. The latter unfortunately records only the power of detrusor action. It does not give information about sphincter co-ordination, which is equally, if not more, important.

Even after reflex activity has appeared there is a phase when the establishment of compensatory mechanisms such as manual compression, abdominal straining, abdominal massage and special postures take further time, and much depends on the ability and co-operation of the patient.

A type of bladder management must therefore be employed which will meet the demands of these potentially long periods, which will keep infection of both the upper and lower urinary tract to a minimum, which will avoid genital sepsis and at the same time permit frequent and easy observation of the state of efficiency of the bladder musculature.

Treatment must be designed primarily to prevent complications and secondly to encourage and reinforce reflex activity. It must continue not to the stage of unaided urine voiding but to the stage of efficient bladder emptying.

These objects can be achieved only by the principles of bladder drainage, bladder lavage, by frequent observation and by instruction of the patient.

Methods of bladder drainage—The various methods of bladder drainage are well known and will not be discussed here apart from comments on experiences gained from the treatment of other patients admitted to the unit.

Drainage by manual compression—It is not considered that the programme of control by manual compression should be used even though the incidence of infection has been thereby reduced in a number of cases. Experience shows that prolonged distension invariably occurs and hydronephrosis and hydro-ureter are early in evidence. This method can also be dangerous in high cord lesions when rupture of the bladder can occur. At its best it may be regarded as a form of retention with expressible overflow of varying amount.

Drainage by intermittent urethral catheterisation—This invariably leads to irregular and varied distension and almost certain infection, and the repeated irritation of the urethra adds even greater risks of infection than those of an indwelling urethral catheter.

Drainage by suprapubic catheter—This method has its advocates (Riches 1943, Donovan 1947, 1949), and it has occasional advantages, but experience gained from cases referred to this unit shows that the sinus always takes three or four weeks to heal and a period of urethral drainage is necessary ultimately. It is not considered that bladder training can be successfully attained while the bladder is attached to the anterior abdominal wall by a tube. The incidence of calculi is high, urine tends to "pond" and the ease with which the bladder is drained leads to a false sense of efficiency. Many suprapubic cystostomies have been maintained until chronic infection, fibrosis and bladder contracture were irreversibly established.

Drainage by perineal urethrostomy—This is only mentioned for the sake of completeness. One case only has been seen and it is thought that the risks of lying in a puddle of urine are far too great to make this theoretically ideal method of bladder drainage a practical possibility.
Drainage by indwelling urethral catheter—All the fifty patients under review have been treated by this method. With it the bladder capacity can be strictly controlled and distension easily avoided. Regular exercise can be given and the interior of the cavity kept clear of debris by bladder lavage. Strict asepsis can keep lower urinary tract infection and genital sepsis at a minimum, and at all times frequent and easy observations can be made on the efficiency of the bladder musculature. A more detailed analysis of this method of bladder management is set out below.

DETAILS OF BLADDER DRAINAGE BY INDWELLING CATHETER

The catheter—The indwelling urethral catheter is of the self-retaining Foley type, usually size 16 or 18 French gauge. This has been well tolerated and any urethral discharge can escape down the urethra alongside the catheter. Meatotomy or dorsal slit has been done where necessary to avoid the train of infection set up by a tight meatus or prepuce. The catheters have been changed each week irrespective of whether they were clean or dirty. To leave them in longer increases the liability of encrustation on the catheter tip and on the balloon in particular. On deflation of the latter phosphatic debris may be left in the bladder base, thus providing a focus for infection and stone formation.

The aseptic handling of the catheter cannot be over-emphasised. Changing is done with sterile forceps and gloves and at all other times a similar strict aseptic technique is followed. The meticulous attention to the details of asepsis is a most vital part of this method.
Drainage—The catheter is attached to a rubber tube, and urine is allowed to flow freely into a drainage bottle beneath the bed except at times when drainage is being controlled by the use of a clip on the tubing during the later stages of bladder retraining.
Irrigation—During its period of inactivity the bladder does not lie completely empty. At this stage it is atonic and rather like an old flat deflated rubber balloon. For this reason it is advisable in the early stages to employ a method of lavage that is certain to empty the bladder cavity at each operation. This has been achieved by suction with a Canny Ryall syringe. Twice daily the bladder had been cleared of debris, distended with half a pint or a pint of solution and then sucked clear of all fluid by the syringe.

The syringe suction is abandoned as soon as the tone of the bladder muscle is sufficient to clear its own cavity of debris and solution during washouts. The syringe is then replaced by a closed manually operated system of irrigation (Nesbit and Gordon 1941, Prather 1947) in which the irrigating solution, irrigating jar and tubing are autoclaved as a single unit. The quantity of fluid used can be easily controlled, and the force of the irrigation is regulated by the height of the reservoir. This operation is repeated several times each day while free drainage is maintained in the intervals. The solution used is Suby's solution M, which has a pH of 5·5 (Suby and Albright 1943).

Tidal drainage (Munro 1943) has not been used because it has often been found to produce a condition of retention with automatic overflow, particularly in the early phases of bladder inactivity. In these circumstances it does not remove debris effectively and the apparatus itself needs much attention.
Manual control of catheter drainage—The manual control of catheter drainage has already been mentioned. A screw clip is applied to the drainage tube and operated by the patient in an endeavour to simulate normal bladder activity. Normal or perverted sensations of bladder fullness can be noted by the patient and at the same time he can practise voiding by abdominal straining or manual compression.

Perverted sensations produced by bladder fullness are common in paraplegia. They may appear as vague suprapubic discomfort, as sweating, as fluttering in the buttocks and in

many other ways. They are all important because they are signs of impending bladder activity and if developed can give sufficient warning to be of practical value to the patient.

Trial periods without a catheter—Each week, when it has been removed for routine changing, the catheter is left out for a trial period of several hours during which observations are made on the bladder's ability to void urine. As soon as some evidence of voiding occurs the trials are continued over longer periods and at the end of each the residual urine is withdrawn and the amount measured. The volume of the residual urine depends on the efficiency of the voiding power of the bladder, and the trial periods without the catheter are continued at weekly intervals until the residual urine is far less than the amount voided at any one time.

At this stage the catheter is left out for several days at a time and the residual urine estimations again repeated at regular intervals until it is apparent that the voiding power is adequate to prevent an insidious increase in the volume of urine left in the bladder.

TABLE I

PERIODS OF CATHETER DRAINAGE

Bony level	Neurological state	Number of cases	Catheter period (*weeks*)	
			Actual	Average
Cervical	Complete	5	2 to 56	20
	Incomplete	6	3 to 16	7
Thoracic	Complete	6	12 to 23	17
	Incomplete	0	—	—
Thoraco-lumbar	Complete	20	2 to 34	19
	Incomplete	5	1 to 13	7
Lumbar	Complete	6	12 to 53	32
	Incomplete	2	2 and 4	3

A residual urine of 25 per cent of the total bladder capacity is regarded as a reasonable amount to allow of cessation of catheter drainage.

Table I shows the duration of the catheter periods which had to be maintained until satisfactory voiding was attained. It will be noticed that all the patients with incomplete neurological lesions had short periods of catheter drainage whereas those with complete lesions had much longer ones, the longest being those in the complete lesions of the cauda equina in which the bladder was isolated from all cord activity.

Therapeutics—Antibiotics were given only for acute infections with constitutional disturbance. Sixteen patients did not receive any antibiotic therapy during the period of catheter drainage. Short courses of urine-acidifying treatment were given in eighteen cases, the acidifying agent being ammonium chloride in doses of fifteen grains three times a day. This was sometimes supplemented with methenamine mandelate. At no time were alkalies used. Twenty-nine patients had more specific therapy, particularly when the newer antibiotics became available. The response was dramatic but relapse was common.

Instruction of the patient—All patients were informed of the importance of recognising dulled or perverted sensations of bladder fullness and to correlate these with impending bladder activity. During the later stages of catheter drainage the patients operated their own screw clips on the drainage tubes in an attempt to simulate bladder action. Urine voiding was reinforced by abdominal straining, deep breathing, and manual compression of the abdomen according to individual circumstances.

Each patient endeavoured to find out in which position he could void best, whether lying, sitting or squatting, and the procedures were repeated during the trial periods without a catheter and subsequently. Advice was also given on control by regulation of the fluid intake and establishment of habit reflexes and other methods of initiating bladder emptying.

RESULTS OF TREATMENT

The early general results (Table II) did not provide any features which were detrimental to bladder control in itself. There were five deaths within two months. One was due to the rupture of a congenital intrathoracic stomach in a stage of paralytic ileus a few days after injury. Two were due to massive pulmonary embolism and two to respiratory failure in high cervical lesions. All the surviving patients had been mobilised to the chair stage by the end of the twelfth week. There were no spinal deformities or secondary neurological complications and—most important of all—there were no skin sores.

The bladder state in the forty-five surviving patients as observed within three months of the end of the period of catheter drainage varied with the site and severity of the

TABLE II

GENERAL RESULTS (FIFTY CASES)

Number of operations		28
First-intention healing of wound		28
Deaths within two months of injury		5
Usual interval before mobilisation to chair stage	*weeks*	8
Spinal deformity		Nil
Pressure sores		Nil

neurological lesion. Nine of the eleven patients with cervical cord lesions lived and achieved some form of reflex bladder action. Six patients with incomplete cervical cord damage acquired voluntary bladder control but with some precipitancy of action. The other three patients with complete cervical cord damage developed uncontrolled bladder action necessitating the use of a portable urinal.

Four of the six patients with complete thoracic cord lesions survived. One patient acquired excellent habit control by means of a careful regulation of his fluid intake. The remaining three developed uncontrolled reflex bladder action which was later converted to the flaccid type by intrathecal alcohol block. This resulted in considerable benefit in two cases but none in the third.

All the twenty-five patients with thoraco-lumbar injuries survived but with considerable variation in bladder control. Five patients with incomplete and nine with complete cord lesions developed voluntary bladder control. The remaining eleven patients did not achieve a state of efficiency that could be regarded as socially safe.

One of the eight patients with cauda equina injuries died. Two of the remainder had almost normal bladder control. Two others were able to void by abdominal straining and did not need a portable urinal, but four were potentially incontinent on all occasions involving muscular effort.

Further treatment has been necessary in certain of the less successful cases and it is hoped to present a report on more radical procedures at a later date.

COMPLICATIONS

Complications during the catheter period—Of the complications (Table III) balanitis and urethritis were mild. The periurethral abscesses were difficult and the fistula that occurred

as a result of one of these took a long time to heal. Epididymo-orchitis occurred in five cases, but this complication occurs at any time and at any stage in the treatment of paraplegia and the incidence has been quoted as high as 20·8 per cent by Bors (1948). The calculi that occurred during the catheter period were all small and easily removed through a direct-vision cystoscope or through metal Bigelows evacuators. They were mainly soft flat stones from one to two centimetres in diameter, frequently showing moulding suggestive of their having been formed round the catheter balloon.

TABLE III

EARLY COMPLICATIONS (FIFTY CASES)

Balanitis	1
Urethritis	7
Periurethral abscess	2
Fistula	1
Stricture	0
Epididymo-orchitis	5
Calculus: urethral	0
vesical	5
renal	1

Infection—Urinary infection almost always occurred though stringent measures were taken to reduce its effects. Five patients who had periods of catheter drainage of less than three weeks did, however, have sterile urine cultures throughout. Thirteen patients had severe urinary tract infections with gross constitutional upset, and twenty-seven had mild infections. The infecting organisms were those of the usual bacterial flora, continually changing both in type and sensitivity to chemotherapeutic and antibiotic agents.

Within a month of the end of the period of catheter drainage ten patients had sterile urine. Ten still had mild infection without constitutional upset, one had a severe and uncontrolled infection, and twenty-four had bacilluria.

SPECIAL INVESTIGATIONS

Excretion pyelography—This was carried out as a routine, and some dilation of the upper urinary tract was noted in seventeen cases. No single factor could be found to account for this complication. It did not accompany all the severe infections; it was found in cases of each group of injuries and it was not definitely related to the amount of residual urine. It was, however, commonest in the patients having isolated and autonomous bladders in which urine voiding was achieved by straining.

Cystoscopy—Both direct-vision and lens-instrument cystoscopy were performed in every case. Most findings were similar to those recorded by many other observers (Bumpus, Nourse and Thompson 1947, Prather 1949) and will not be repeated. Special attention was paid to the state of the region of the external sphincter. At this level resistance to the passage of the instruments was noted in thirteen patients, all of whom had heightened reflex activity in the isolated distal segments of the cord below the level of their injuries. Contractions of the sphincter could be invoked by producing general reflex spasm and a definite ridge was observed to appear in the urethra at the level of the external sphincter.

Bladder neck contracture at the level of the internal sphincter was uncommon at this early stage of bladder readjustment. When it occurred it was resilient and easily passed by the instruments.

COMMENTS

It is appreciated that this method of bladder management is well known and its comparative merits have frequently been discussed. From the experience gained from these and other cases it cannot be sufficiently emphasised that the handling and changing of the catheters must be controlled by a strict and regular aseptic routine. This routine must be observed at all times, whether the occasion be the daily catheter and meatal toilet at the time of bladder washouts or the operations for catheter introduction or replacement.

Great importance is also attached to the emptying of the bladder during its phase of atonicity. This is the time when debris and residual urine are not easily removed by methods of irrigation other than syringe suction.

The great reduction of vesical calculi in this group of cases is attributed to the strictly aseptic catheter routine and the special attention to bladder emptying during and after washouts. The high fluid intake and early general mobilisation is considered largely responsible for the almost complete absence of renal calculi.

It has undoubtedly been an enormous advantage to have these cases admitted early to the unit and thus to have the management of all aspects proceeding concurrently. Similarly the management of many cases by the same staff has facilitated comparative observations and standard procedures. The absence of bedsores has cut out all delays in mobilisation and has reduced the incidence of toxaemia and sepsis so often seen in less fortunate circumstances.

The results obtained in the forty-five surviving patients have been better than those obtained in the same number of patients treated by other methods. The incidence of severe infection has been much reduced, as have the number of calculi. The early bladder state after catheter drainage has been more efficient and subsequently has required less attention in the way of surgical or other corrective procedures.

Although the improved results of bladder management are reflected in the equally improved successes of treatment the statement is just as true when put the other way round. Indeed the treatment of paraplegia must continue to be regarded as a single entity with detailed attention to each integral part.

I am indebted to Mr J. C. Anderson and members of the Urological Department of the Royal Hospital, Sheffield, for their encouragement, advice and technical assistance in connection with these cases.

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PARALYTIC DISLOCATION OF THE HIP

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Paralytic dislocation of the hip deserves recognition as a special problem; it should not be grouped loosely with other types of pathological dislocation. Yet few writers seem to have thought the paralytic cases worthy of separate consideration. Hilton (1879) said: " The acetabulum in a child is very shallow compared with that of an adult. It thus offers greater facility for displacement. This, I apprehend, may be the reason why dislocation of the thigh bone occurs so frequently in hip joint disease at an early period of life." Watson Jones (1926) discussed the mechanism of flexion and adduction deformity in spontaneous dislocation of the hip; he concluded that a combination of both forces was necessary, but that adduction was the more important, flexion alone not producing dislocation. Medial rotation did not seem to be important. Hart (1928) was in agreement with this view. Fairbank (1920) however reported the case of a patient with a flail hip in which reducible subluxation occurred. He remarked that all cases he had seen before had had paralysis of the abductor muscles but active adductors.

This paper records a study of twenty-two paralytic dislocations of the hip in fourteen patients. The causes of the paralysis are shown in Table I.

TABLE I

CAUSE OF PARALYSIS IN TWENTY-TWO CASES OF PARALYTIC DISLOCATION OF THE HIP

	Patients	Hips
Poliomyelitis . .	4	6
Spastic paraplegia .	7	12
Spastic hemiplegia .	2	2
Meningo-myelocoele	1	2

Insufficient attention seems to have been paid to the element of coxa valga which is always present. This is most marked if paralysis was present in the first two years of life and appears to be due to the weakness of the moulding forces of muscle action and of weight bearing. Of the two it seems probable that the influence of the muscles is the more important, because the change is still seen in cases in which weight bearing has been possible.

Piersol (1930) stated that the normal angle of the neck of the femur with the shaft ranges from 110 to 144 degrees in adults, the average for men being 125·1 degrees and for women 125·6 degrees. " At birth the angle of the neck may be 160 degrees, but is often less; it diminishes under the pressure of the weight as the child walks, and by the time of puberty has probably assumed its permanent angle." In a study of normal radiographs of the hips of twenty-five subjects between the ages of a few weeks and five years I have confirmed this, but it is also apparent that the major part of the reduction in the angle occurs during the first five years of life.

Observation of cases of paralysis in which dislocation later develops shows that the neck-shaft angle increases to nearly 180 degrees, when dislocation becomes inevitable, being uninfluenced by any form of treatment except surgery. Over-action of the adductors hastens dislocation but dislocation will occur when there is complete flaccid paralysis without contracture. The femoral head progressively rides out of the acetabulum and the subsequent growth of the femoral neck may bring it into alignment with the femoral shaft or even beyond. The empty acetabulum, although gradually becoming more shallow, remains of useful depth for several years. This has been seen at operations in nine hips. When the dislocation is beginning it can be reduced easily by simple abduction. In the later stages a contracture of the capsule and of the ilio-psoas muscle appears, so that after four or five more years it becomes irreducible by traction or manipulation.

In this study of the problem it is concluded that the primary factor in the development of paralytic dislocation is the development of a valgus deformity of the femoral neck, and that, once this has happened, dislocation is inevitable. The presence of the valgus element in such cases is well recognised by other writers, but its importance in relation to treatment does not appear to have been recognised sufficiently.

ILLUSTRATIVE CASE REPORTS

Case 1—Boy first seen two months after birth. Massive meningo-myelocoele in lumbar region and hydrocephalus. Early radiographs showed normal hip joints. At operation on the meningo-myelocoele so much nerve tissue was removed in order to effect a closure that a permanent complete flaccid paralysis resulted. Radiographs four months later (at the age of six months) showed subluxation of both hips, with coxa valga (Fig. 1). A year later the subluxation was easily reducible in full abduction and the acetabula were still quite good (Fig. 2). Further radiographs two years later showed that the femoral necks were growing in line with the shafts and further displacement had occurred (Fig. 3). Figure 4 (at the age of seven years) illustrates the fully developed coxa valga, dislocation and shallowing of the acetabula. The dislocation was now irreducible by traction and abduction. In view of the complete and permanent paralysis of the lower limbs, it has not been thought wise to contemplate surgical reduction in this case.

Comment—This case exemplifies the development of coxa valga and later dislocation of both hips in complete flaccid paralysis of both legs.

Case 2—Girl with cerebral palsy. First seen at the age of six months with marked spasticity of both lower limbs and mild spasticity of arms. Good voluntary movements in all four limbs. Treatment by daily stretching and encouragement of active movements was begun. At eighteen months there were no contractures; calipers were supplied, and standing at a table with the legs moderately abducted was begun. At the age of three she was making moderately good attempts at walking with assistance in calipers. Pain in the left hip was then noted, with increased difficulty in standing and attempting to walk. Radiographs showed well developed coxa valga and subluxation of the left hip (Fig. 5). There was no adduction contracture; so a left obturator neurectomy was carried out. Three months later the result seemed satisfactory (Fig. 6). However, with such a degree of coxa valga dislocation was inevitable on both sides as shown in Figure 7 (age five) and Figure 8 (age six), in spite of the absence of contracture and weight bearing in calipers. At this stage simple abduction produced reduction of the dislocation (Fig. 9) and it was decided to carry out a corrective osteotomy below the femoral neck on both sides. Fixation of the osteotomy was secured by miniature Capener-type nail-plates. The nail-plates were removed six months later. Figure 10 shows the present condition two years later. This child can now get about unaided and the hips are quite stable with a full range of movement.

Comment—This case illustrates the inevitability of dislocation once the coxa valga deformity has appeared.

Case 3—Girl. Developed poliomyelitis four months after birth, with severe paralysis in trunk and lower limbs. Seventeen months later she was able to sit up (with some scoliosis) but unable to walk, stand or crawl. The muscle chart (Table II) showed the condition of the muscles controlling the hips. Radiographs showed bilateral dislocation of both hips (Fig. 11). The dislocation is attributed to valgus deformity of the neck of the femur in the absence of the moulding forces of muscular action. There was no rotational deformity and dislocation was easily reduced by abduction of the legs (Fig. 12).

FIG. 1

Case 1—Age six months. Coxa valga. Early subluxation of both hips.

FIG. 2

Case 1—Age eighteen months. Reduction by simple abduction.

FIG. 3

Case 1—Age three and a half years. Recurrent subluxation.

FIG. 4

Case 1—Age seven. Fully developed coxa valga with dislocation.

FIG. 5
Case 2—Age three and a half. Coxa valga. Subluxation of left hip.

FIG. 6
Case 2—Three months later, after reduction and obturator neurectomy.

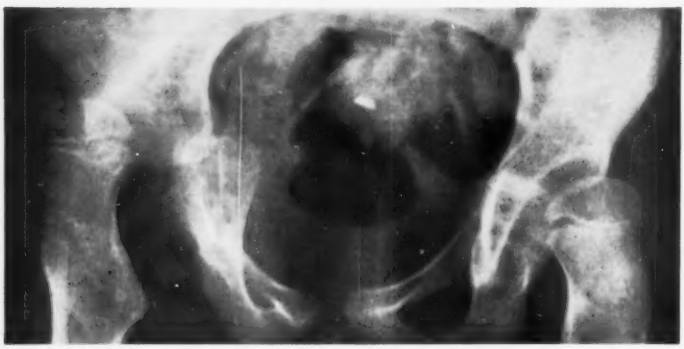

FIG. 7
Case 2—Age five. Dislocation of right hip.

FIG. 8
Case 2—Age six. Redislocation of left hip.

FIG. 9
Case 2—Age six. Reduction by abduction.

FIG. 10
Case 2—Condition two and a half years after correction of coxa valga by osteotomy.

FIG. 11
Case 3—Age nineteen months. Bilateral coxa valga. Dislocation of both hips.

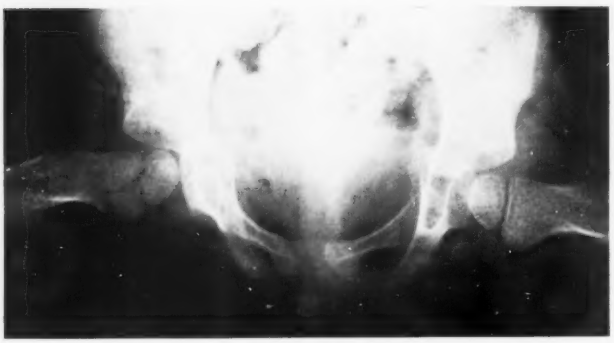

FIG. 12
Case 3—Reduction by abduction of limbs.

FIG. 13
Case 3—Eighteen months after correction of coxa valga on each side by osteotomy.

Osteotomy of the femoral necks was carried out, the right side at the age of two years and the left side three months later, restoring the normal neck-shaft angle of the femur. Fixation of the upper fragment was obtained by transfixion by a Steinmann pin incorporated in a double plaster hip spica, the bones being so small that the use of miniature nail-plates was not considered practicable. The osteotomy on the left side was carried out rather higher in the neck than would be recommended; union was a little slow, but no evidence of damage to the circulation of the femoral head was observed.

The present condition eighteen months after the operations is shown in Figure 13. The muscle chart (Table II) illustrates the substantial gain in muscle power now that the hips are reduced. She is able to walk unaided using appliances below the knees only to control the paralytic deformity of the feet.

TABLE II

MUSCLE CHART IN CASE 3

	Age 12 months		Age 30 months		Age 41 months	
	Right	Left	Right	Left	Right	Left
Gluteus maximus	2	2	4	3	4	4
Abductors of hip	3	2	4	4	4	4
Adductors of hip	3	3	4	3	4	4
Psoas . .	3	3	4	3	4	3
Quadriceps* .	3	3	4	4	4	4
Inner hamstrings	2	2	2	2	2	2
Outer hamstrings	2	2	2	2	2	2

* Mainly rectus femoris.

Operations: Right hip at age twenty-three months.
Left hip at age twenty-six months.

Comment—The implications of structural hip instability together with muscular weakness are so serious that they may mean the difference between the ability to get about independently or not. This case illustrates well the increase in effective power of weak muscles as a result of restoring hip stability by osteotomy of the femoral neck, correcting the coxa valga.

OPERATIVE TREATMENT

Corrective osteotomy below the femoral neck with internal fixation—This operation is suitable for cases in which reduction of the hip dislocation can be obtained by simple abduction; which is possible when the dislocation is recent. In somewhat later cases, with tight adductors, the adductor contracture can often be overcome by adductor tenotomy and a short pre-operative period in an abduction plaster. It should be possible before operation to abduct the legs enough to allow the line of the femoral neck to make an angle of 120 degrees or less with the mid-line of the body.

The operation is carried out through a postero-lateral approach with the patient prone, the femur being exposed at the level of the lesser trochanter. A triangular wedge of femur with the base inwards is resected, the apical angle being equal to the angle of correction required. The base of the wedge should be as low in the femoral neck as possible and should include the upper half of the lesser trochanter. Correction having been thus obtained, internal fixation is easily carried out with a miniature nail-plate of the Capener type. If the bones are too small for this, the upper fragment is transfixed by a Steinmann pin which is

incorporated in the double hip spica applied at the end of the operation. The plaster is retained until the osteotomy is united. The nail-plate is removed six months after operation, before it becomes too deeply embedded in the growing bone. Some form of internal fixation has been found essential to control the unstable osteotomy.

Open reduction, wedge osteotomy below femoral neck, femoral shortening, and internal fixation—This operation was devised for the late case with contracture, in which

FIG. 14
Case 4—Age 8. Coxa valga. Dislocation of both hips.

FIG. 15
Case 4—After open reduction of the dislocations, wedge osteotomy to correct coxa valga, and femoral shortening.

the dislocation is irreducible even after a period of strong traction and gradual abduction with adductor tenotomy. The need for this operation should not arise if the dislocation is recognised early enough. In three operations of this type the limiting factor preventing reduction has been found to be contracture of the ilio-psoas muscle.

With the patient supine the hip is exposed by the Whitman incision, and division of the tensor fasciae latae gives a good exposure of the osteotomy site. It is necessary first to lengthen

the ilio-psoas tendon, then to excise the whole of the anterior and inferior capsule. Even then it is not possible to reduce the femoral head into the acetabulum until the osteotomy has been carried out as already described. The upper fragment is then transfixed with the nail-plate, and it remains to shorten the femur by half to three-quarters of an inch before satisfactory fitting can be obtained. Immobilisation in plaster is necessary until union has occurred. This is a formidable operation which is only justified if the possibility of walking depends upon it. The upper limit of age for this procedure is about ten years.

ILLUSTRATIVE CASE REPORT

Case 4—Girl with cerebral palsy. She had spastic quadriplegia and came under regular physical treatment and supervision at the age of one year. A child of moderate intelligence who was capable of good voluntary movement, she had learnt to stand but made no progress in walking. When she was seen at the age of eight years both hips were found to be dislocated (Fig. 14). When she was nine it was decided that she would never succeed in walking with unstable hips and that reduction might provide a chance of achieving this. Reduction could not be obtained by traction and abduction. The second operation described above was therefore carried out, first on the right hip and, after union of this osteotomy, on the left (Fig. 15). It was felt that there would be a risk of hip stiffness after this operation, but she has already regained 60 degrees of flexion on both sides and the hips are stable. Whether she will eventually succeed in walking unaided remains to be seen.

RESULTS

Only those cases in which there seemed to be a possibility of establishing independent walking by restoring stability to the hips have been chosen for operation. Nine hips in six patients have been so treated within the last two years. Two patients, previously with bilateral dislocation, unable to walk, are now walking unaided with a full range of movement in both hips (Cases 2 and 3). A third bilateral case (Case 4) shows promise. In the three unilateral cases two patients have been greatly improved in stability and ability to walk, but the third is still too recent to assess.

DISCUSSION

The follow-up of these cases is short, but it was felt that the material contained in this paper might prove of interest and help to others confronted with similar problems, even at this stage. If coxa valga and early dislocation are recognised, simple osteotomy of the femoral neck should remove many later difficulties, but it must be recognised and be dealt with early.

As the femur goes on growing after the osteotomy, it seems likely that there will be some tendency to recurrence of the deformity of the femoral neck, but it is hoped that this will be minimised by the improved muscle function and effect of regular weight bearing so that actual dislocation will not recur. In support of this statement, it should be noted that when paralysis occurs after the first two years of normal development, a mild degree of coxa valga is seen and dislocation is extremely rare. All twenty-two dislocations in the present series occurred in patients who had paralysis during the first two years of life.

Avascular necrosis of the femoral head has not been seen in the hips operated upon, and probably this risk is slight if the osteotomy is kept low enough. The only alternative to osteotomy is shelf stabilisation as described by Hallock (1942) and Le Vay (personal communication). The treatment of the basic deformity of coxa valga is more logical.

SUMMARY

1. Twenty-two dislocations of the hip occurring in patients paralysed from an early age have been studied. All showed abnormal coxa valga. The coxa valga, which may gradually reach 180 degrees, precedes dislocation and makes it inevitable. The presence of unbalanced adductor power may hasten dislocation, but the latter can occur in complete flaccid paralysis.

2. The combination of structural instability of the hip joint and muscular weakness may make independent walking impossible, but restoration of stability gives considerable improvement in any remaining muscular power and may alter the patient's whole future. 3. A method of correcting the basic deformity of coxa valga by osteotomy is described and the results of nine operations are reviewed.

I am indebted to Mr F. J. Suter, of the Devonian Orthopaedic Association Workshops, for making the miniature nail-plates, and to Mr A. Reaney, M.S.R., for the illustrations. I am grateful to my colleagues at the Princess Elizabeth Orthopaedic Hospital, Exeter, and Mount Gold Orthopaedic Hospital, Plymouth, who have given me the opportunity of observing and treating their cases.

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CONGENITAL DYSPLASIA OF THE HIP

Observations on the " Normal " Joint in Cases of Unilateral Disease

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Since the work of Putti (1929) the subject of preluxation or dysplasia of the hip which is the forerunner of true dislocation has been widely covered in numerous papers published during the second quarter of this century. The recent monograph of Hart (1952) contains a comprehensive summary of our present knowledge of this problem.

There is but one feature which seems to have escaped notice—namely, the condition of the opposite hip in cases of unilateral dysplasia.

While examining infants with signs of unilateral preluxation, I was impressed by the persistent abduction attitude assumed by the opposite hip. The contrast with the adducted, dysplastic hip was striking. On closer examination a more or less pronounced abduction-contracture was evident.

It is the purpose of this paper to consider a series of fifty-one infants all presenting this singular association of a one-sided congenital dysplasia of the hip with an abduction-contracture of the opposite joint; and, further, to suggest an explanation for the pathogenesis of unilateral dysplasia.

CLINICAL AND RADIOLOGICAL FINDINGS

These infants were referred to the specialist because of one or more of the following features: asymmetry of the skin-creases of the thighs, a lessened tendency to move one leg spontaneously, or the shortening of one lower extremity. On examination, in addition to the features mentioned, passive abduction of the hip on the shortened side was found to be limited.

The radiographs disclosed the following abnormalities on the shortened side: obliquity of the acetabular roof, lateral and upward displacement of the femur, and sometimes a retardation in the ossification of the bony nucleus of the head.

The picture so far described is typical of congenital dysplasia of the hip and the only purpose of its recording was to show that in this respect our cases did not differ from those previously described. But when attention was turned from the dysplastic hip to the opposite one the habitual abduction attitude of the latter could not escape notice.

Left to himself the infant assumed immediately his favourite position: the apparently sound leg drawn up in a slightly flexed and clearly abducted attitude whereas the dysplastic one remained adducted (Figs. 1 and 2). There was also an obvious difference in spontaneous movement of the legs, the abducted one being by far the more mobile. This abducted position is also clearly seen in the radiographs.

When both legs were brought together by the examiner the difference in length was manifest, the abducted extremity appearing to be the longer. There was a downward tilt of the pelvis towards the abducted side as evidenced by the lowering of the anterior superior iliac spine on that side. This pelvic tilt was better appreciated in the prone position, in which the natal cleft was seen to be angulated from the mid-line of the body. Routine measurement of the extremities confirmed the impression that the difference in length was not a true discrepancy.

On closer examination this abducted position of the " normal " hip was seen to be due to a contracture of the hip abductors. The slightest attempt at passive adduction of the

" normal " leg either increased the existing pelvic tilt or, when the latter was prevented by fixation, failed to bring the limb closer to the midline. This was in complete contrast to similar manoeuvres performed on the dysplastic side (Figs. 3 and 4).

FIG. 1

FIG. 2

Habitual attitude of an infant aged four months: abduction-contracture of the right hip, dysplasia of the left hip.

FIG. 3

FIG. 4

Manoeuvre used for testing an abduction-contracture of the hip while fixing the pelvis with the flexed contralateral leg: on the right (contracted) side the limb cannot be brought near the midline (Fig. 3). Compare with the left or dysplastic side (Fig. 4).

The clinical findings can be summarised as follows. Besides the unquestionable unilateral dysplasia of the hip all our cases presented a more or less pronounced but always easily recognisable abduction-contracture of the opposite " normal " hip, with a downward pelvic obliquity towards the abducted side.

CLINICAL MATERIAL

This series concerns fifty-one infants aged from one week to ten months. The distribution according to age is given in Figure 5, which shows that more than half of the total number were aged between two and five months. Most were seen first at the age of three to four months. Distribution according to sex reveals the overwhelming majority of the female sex (forty-eight girls and three boys). The right and left hips were almost equally affected by the dysplasia (twenty-three right, twenty-eight left hips). No instance of hereditary involvement was noted.

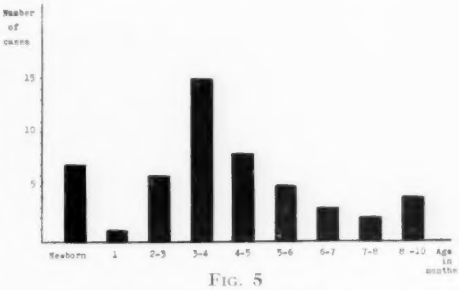

FIG. 5
Distribution according to age.

The degree of abduction-contracture, the degree of dysplasia, and their respective evolution according to age are shown in Table I. Most of the patients showed a moderate degree of abduction-contracture and only in five instances was the contracture marked, four of them in infants below the age of four months.

More than half of the total number showed what was termed a moderate degree of dysplasia: that is, all the usual signs of this malformation were present without exaggeration of any special feature. In eighteen cases the dysplasia was slight, not all of the classical

TABLE I

DEGREE OF ABDUCTION-CONTRACTURE, DEGREE OF DYSPLASIA AND THEIR RESPECTIVE EVOLUTION ACCORDING TO AGE

Age	No. of cases	Degree of abduction-contracture			Evolution of abduction-contracture		Degree of dysplasia			Evolution of dysplasia			
					Regression					Spontaneous recovery	Response to treatment		Dislocation
		Slight	Moderate	Marked	Rapid	Slow	Slight	Moderate	Marked		Rapid	Slow	
Newborn	7	—	6	1	6	1	6	1	—	6	—	—	1
1 month	1	1	—	—	1	—	1	—	—	1	—	—	—
2–3 months	6	—	5	1	—	6	—	5	1	—	2	3	1
3–4 months	15	2	11	2	2	13	5	10	—	4	9	2	—
4–5 months	8	2	6	—	2	6	2	4	2	—	6	2	—
5–6 months	5	—	5	—	—	5	—	4	1	—	4	1	—
6–7 months	3	—	2	1	—	3	—	3	—	—	2	1	—
7–8 months	2	1	1	—	—	2	—	1	1	—	1	1	—
8–10 months	4	2	2	—	2	2	4	—	—	2	2	—	—
Total	51	8	38	5	13	38	18	28	5	13	26	10	2

signs being present at the time of the first examination. Five infants showed a marked degree of dysplasia in which some or all of the habitual features were unusually prominent. The follow-up period ranged from six months to one and a half years.

The evolution of the abduction-contracture was towards spontaneous regression—rather slowly, perhaps because the treatment of the opposite dysplastic hip maintained abduction.

The evolution of the dysplasia ranged from spontaneous recovery to the development of a true dislocation. Spontaneous recovery was noted in thirteen patients, in whom all of the signs of dysplasia regressed in eight to ten weeks. Rapid response to treatment by abduction

FIG. 6

Case 1—At the age of three months: marked abduction-contracture of the right hip, moderate dysplasia of the left hip.

FIG. 7

Case 1—At the age of six months, after three months' treatment by abduction splint: perfect restitution of the left hip.

splint was noted in twenty-six infants. In three to four months restitution to normal was complete (Figs. 6 and 7).

In ten infants the response to treatment was rather slow and the abduction splint had to be applied for a period varying from six months to one year (Figs. 8 and 9). The development of a true subluxation or dislocation occurred in two instances. The reports are given in detail.

CASE REPORTS

Case 3—Girl. First examination a few days after birth. Marked abduction-contracture of the right hip; moderate dysplasia of the left hip, in which the main feature was the lateral and upward

FIG. 8

Case 2—At the age of two months: marked abduction-contracture of the right hip, marked dysplasia of the left hip.

FIG. 9

Case 2—At the age of fourteen months: after one year of treatment by abduction splint there is a normally shaped acetabulum but the bony nucleus of the head is notably hypoplastic.

displacement of the femur. At that time no difference in the acetabular index was present. At the end of the first month a true subluxation was evident in the left hip and the acetabular index was greater on that side, indicating flattening of the acetabular rim. The abduction-contracture of the right hip was slow in regressing, as was the reduction and subsequent development of the left hip. Not until the age of one year was recovery complete (Figs. 10 to 12).

FIG. 10

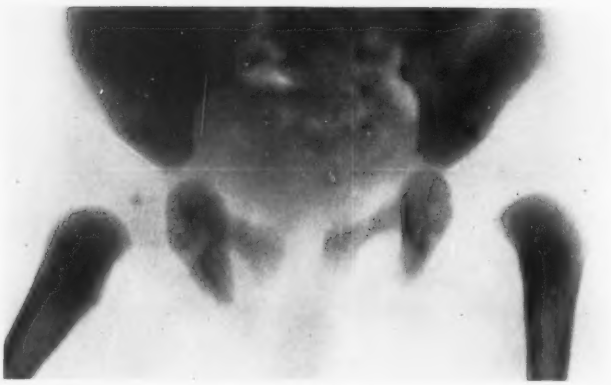

FIG. 11

FIG. 12

Case 3. Figure 10—Immediately after birth: marked abduction-contracture of the right hip, moderate dysplasia of the left hip. There is no difference in the acetabular index. Figure 11—At the age of one month: the abduction-contracture of the right hip is still marked. The left hip is subluxated: there is a difference of 8 degrees in the acetabular index, the left acetabulum being more oblique. Subluxation persisted for several months despite treatment in abduction. Figure 12—At the age of one year: normal appearance of the left hip.

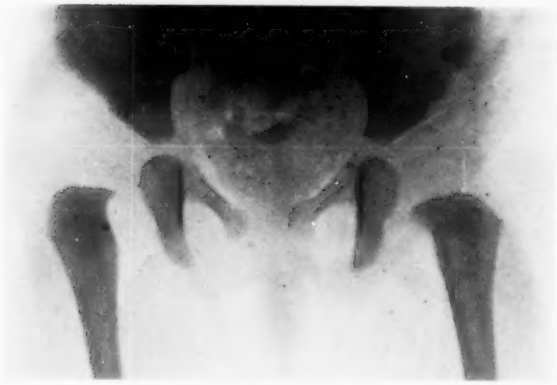

FIG. 13

FIG. 14

FIG. 15

Case 4. Figure 13—At the age of two months: moderate abduction-contracture of the left hip, moderate dysplasia of the right hip. By the time the child was four months old the abduction-contracture of the left hip had regressed. Figure 14—At the age of five months: true dislocation of the right hip. Figure 15—At the age of eleven months: after treatment by plaster the dislocation is reduced but acetabular growth is still inhibited. Three months later normal development was achieved.

Case 4—Girl. First examination at the age of two months. Moderate abduction-contracture of the left hip, moderate dysplasia of the right hip. At the age of four months the abduction-contracture had notably regressed whereas the dysplasia of the right hip had progressed until at the age of five months a true dislocation was evident. It is noteworthy that from the time of the first examination the child was treated by an abduction splint which did not seem to alter the natural

FIG. 16

FIG. 17

Radiographs of two newborn infants showing abduction-contractures, each of the left hip. There is no difference in the acetabular index in either case. The subsequent examinations showed a slight degree of dysplasia, which regressed spontaneously, on the side opposite the abducted hip.

evolution. Only after treatment by plaster was the dislocation reduced and subsequent normal development of the hip achieved (Figs. 13 to 15).

Comments on abduction-contracture of the newborn—Cases of abduction-contracture in the newborn deserve a few remarks. Apart from the one already reported (Case 3) the others developed only a slight degree of dysplasia which regressed spontaneously. The only feature

common to all of them was the absence of any difference in the acetabular index immediately after birth (Figs. 16 to 19). The relatively large number of these cases seems to indicate that the incidence of abduction-contracture in the newborn may be high if it is deliberately searched for.

FIG. 18

FIG. 19

Two further examples of abduction-contractures in newborn infants, each affecting the right hip. There is no difference in the acetabular index. Dysplasia was apparent later in the opposite hip.

The relationship of the degree of abduction-contracture to the degree and evolution of the dysplasia in the opposite hip is shown in Table II. In some instances there is a direct relationship between these features, especially when they are very slight or strikingly severe. In most of the cases, however, these features seem unrelated. The impression gained from

this study is that abduction-contracture and dysplasia evolve independently. But whereas the course of the abduction-contracture was regular and directed towards gradual regression, that of the dysplasia was not predictable, ranging from spontaneous regression to true dislocation. Neither the degree of abduction-contracture in the opposite hip nor the degree of initial dysplasia gave any indication of the possible course of events.

TABLE II

RELATIONSHIP BETWEEN THE DEGREE OF ABDUCTION-CONTRACTURE AND THE DEGREE AND EVOLUTION OF THE DYSPLASIA

Degree of abduction-contracture	Number of cases	Degree of dysplasia	Evolution of dysplasia	Number of cases
Slight	8	Slight	Spontaneous recovery	3
		Slight	Rapid response to treatment	4
		Marked	Slow response to treatment	1
Moderate	38	Slight	Spontaneous recovery	10
		Moderate	Rapid response to treatment	19
		Moderate	Slow response to treatment	5
		Marked	Slow response to treatment	3
		Marked	Dislocation	1
Marked	5	Slight	Rapid response to treatment	1
		Moderate	Rapid response to treatment	2
		Marked	Slow response to treatment	1
		Marked	Dislocation	1

DISCUSSION

The coexistence of unilateral dysplasia and of an abduction-contracture in the opposite hip strongly suggests an etiological relationship. In my opinion it is the abduction-contracture in one hip that leads to the dysplasia in the other. This opinion is based on the chronological sequence in the appearance of these two features and on their respective evolution.

There is no doubt that the abduction-contracture, which represents a retention of a foetal position (Badgley and O'Connor 1953) is present at birth. The evidence of my cases in newborn infants not only corroborates this statement but also suggests that flattening of the acetabulum, generally considered as the primary sign of the dysplasia, is not present at birth. In one of these cases (Case 3) there was an obvious displacement of the femur immediately after birth, but the flattening of the acetabulum was not apparent until the end of the first month. This case emphasises that the only primary feature of dysplasia, present at the earliest moment and contemporary with abduction-contracture in the opposite hip, is upward and lateral displacement of the femur. This displacement can be explained only by relating it to the existence of the abduction-contracture in the opposite hip.

The explanation, indeed, may be sought in an analogous situation—namely, in the abduction-contracture of the hip complicating poliomyelitis. This analogy is quite valid because the mechanics involved are totally independent of the degree and distribution of the paralysis. Mayer (1931) was the first to describe fixed pelvic obliquity from contracture of the hip abductors. Irwin (1947) analysed the faulty mechanics present in the development of a fixed pelvic obliquity caused by an abduction-contracture of one hip. He pointed out

that so long as the contracted extremity is held in the abducted position the deformity remains localised and has no secondary effects on other parts of the locomotor system. But when the contracted extremity is brought alongside its fellow for weight bearing there is a disturbance of all the normal weight bearing lines, above and below the pelvis. Among the changes that take place in this occurrence the displacement of the femoral heads should be emphasised. Whereas the femoral head on the side of the abduction-contracture is lowered and shifted towards the mid-axis of the body, the femoral head on the opposite side is correspondingly elevated and displaced farther than normal away from the midline. An apparent difference in length of the two extremities is present. The abductors on the side opposite the contracture are stretched and their strength is decreased. The resemblance between the schematic drawings published by Irwin (1947) and the radiographs of our patients is remarkable.

Thus the existence of an abduction-contracture in one hip brings about the upward and lateral displacement of the femoral head on the opposite side, provided the abducted extremity is brought into weight-bearing position—alongside the other one. This accounts for the fact that as long as the hips are held flexed—as during intra-uterine life or immediately after birth—abduction-contracture or dysplasia cannot be easily detected unless the condition is very marked. At the end of the first or second month, when the legs are sufficiently extended both by the spontaneous movements of the infant and by the continuous external pressure of the diapers, the discrepancy in length becomes more obvious.

The fixed pelvic obliquity which leads to the upward and lateral displacement of the femoral head and the stretching of the abductors produces the fundamental features of the dysplasia in the hip opposite the abduction-contracture. Occurring as they do at a time when the growth potential is at its height, they will rapidly lead to secondary adaptive changes which will complete the clinical and radiological features of dysplasia. These are the adaptive shortening and over-action of the adductor group, the elongation of the articular capsule and the flattening of the acetabular rim, the last being the result of inhibition of bone growth at the point of abnormal pressure of the displaced femoral head.

I conclude, therefore, that unilateral abduction-contracture of the hip can be responsible for the appearance of signs of dysplasia in the opposite hip, the faulty mechanism being that of " fixed pelvic obliquity." This conclusion may be followed by two considerations. The first stems from the particular evolution of these features. Whereas the abduction-contracture regresses spontaneously and usually disappears at about the sixth month, the dysplasia of the opposite hip sometimes progresses to its obvious outcome—the true dislocation. When seen at a more advanced age (one year or more) these patients would then present the picture of a unilateral dislocation and nothing abnormal would have been detected in the opposite hip. Such a situation can easily be illustrated in two of our cases (Case 3 and Case 4) if we ignore the early radiographs.

In view of this it is very tempting to consider all unilateral dislocations as the result of an unrecognised and long-regressed abduction-contracture of the opposite hip. Appealing as this hypothesis may be, there is not enough statistical proof to substantiate it.

The second consideration refers to the premonitory significance of abduction-contracture shortly after birth. Whenever such a contracture is present, dysplasia is likely to develop on the opposite side and therefore great care should be exercised in the follow-up of these infants.

CONCLUSIONS AND SUMMARY

1. The examination of fifty-one infants presenting signs of unilateral dysplasia (preluxation) of the hip disclosed the existence of an abduction-contracture in the opposite " normal " hip.
2. The abduction-contracture was not infrequently found in the newborn, but seemed to attract attention mostly between the second and fifth month of life. It was seldom found after the sixth month.

3. The dysplasia in the contralateral hip showed the usual features.
4. The relationship between the degree of abduction-contracture and the degree of dysplasia was a direct one only occasionally; in most cases they seemed unrelated to each other.
5. Observation of these patients showed that the abduction-contracture followed a constant course towards gradual and spontaneous regression. The dysplasia progressed in one of the following directions: spontaneous recovery, rapid or slow recovery with treatment by abduction splint, subluxation, or true dislocation.
6. It is submitted that the coexistence of unilateral dysplasia of the hip and abduction-contracture in the opposite hip is not fortuitous. It is believed that the abduction-contracture determines the development of the dysplasia in the opposite hip through the faulty mechanics caused by "fixed pelvic obliquity."
7. The discovery of unilateral abduction-contracture soon after birth should be a warning that dysplasia may develop in the opposite hip. A careful watch should therefore be kept for signs of abduction-contracture and for the later development of dysplasia.

I wish to express my thanks to Sir Harry Platt for his kindly advice and to acknowledge with thanks the help of Dr A. Schoenfeld of the Government Hospital "Zahalon," Tel-Aviv, in recording the cases of the newborn.

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INJURIES OF THE ATLAS AND AXIS

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This paper is presented to show some of the problems encountered in the diagnosis and management of injuries of the upper two cervical vertebrae. It is based on a review of all such injuries treated at Addenbrooke's Hospital, Cambridge, in the last ten years.

ANATOMY

The atlanto-axial articulation is unique in allowing a wide range of rotation, for which the shape of the articular surfaces and their ligaments are specially adapted. The lateral articular surfaces face downwards and forwards, so that rotation of the atlas upon the axis is accompanied by slight vertical descent of the head. The cruciate ligament, composed of transverse and vertical bands, is chiefly responsible for maintaining the odontoid process

Fig. 1

Fig. 2

Radiographs of dissected specimen of upper cervical spine. Dura outlined with barium sulphate. Figure 1—Normal. Figure 2—After forcible anterior displacement. The odontoid process caused indentation of the front of the spinal cord.

in its correct position. The alar and accessory atlanto-axial ligaments help to limit extremes of rotation, and because of the oblique direction of the lateral atlanto-axial joint surfaces this action is delayed by flexion of the head. The central articulation between the odontoid process and the atlas is a synovial joint. Its ligaments are covered by a strong band, the membrana tectoria. Posteriorly the atlas and axis are connected by a ligament in series with the ligamenta flava; it is pierced by the second cervical nerve, which is thus sometimes involved in injuries of the atlas (Jefferson 1920). The spinal cord is suspended from each side of the vertebral column by the denticulate ligaments. It is in close relationship with the back of the odontoid and with the arch of the atlas.

In a fresh necropsy specimen from an elderly subject the transverse and accessory

ligaments were divided. It was found that considerable force was required to cause displacement of the atlas (Figs. 1 and 2). It must therefore be presumed that there is laxity of all the ligaments between the atlas and axis in cases of spontaneous dislocation.

Development—The atlas is ossified from three primary centres, one for each lateral mass and

FIG. 3

FIG. 4

Figure 3—Radiograph showing centres of ossification present at eleven days. Figure 4—Radiograph showing centres of ossification present at five and a half years.

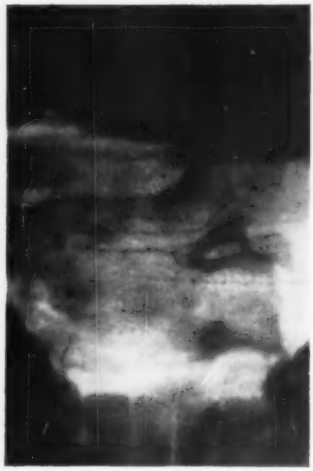

FIG. 5

FIG. 6

Congenital abnormalities. Figure 5—Absence of the anterior arch of the atlas. Figure 6—Fusion of the upper three cervical vertebrae.

one for the anterior arch. The axis is developed in seven centres. The five primary centres comprise two for the vertebral arch, one for the body, and two lateral centres from which the base of the odontoid is formed. The peg of the odontoid is developed from secondary centres which unite with the base of the odontoid process at the twelfth year.

At birth the odontoid is represented only by its lower two centres of ossification (Fig. 3). Figure 4 shows the appearances in a child of five and a half.

RADIOGRAPHIC EXAMINATION

The routine projections used in this study are the antero-posterior and lateral. The antero-posterior radiograph is best taken through the open mouth. Plain radiographs do not always exclude the possibility of subluxation between the atlas and axis (Swanberg 1919). Jackson (1950) radiographed fifty normal adults and fifty children and measured in each the distance between the anterior arch of atlas and the odontoid process. In adults the average distance was 2·5 millimetres but in children it varied up to 4·5 millimetres.

In the interpretation of the radiographs the possibility of congenital abnormalities should be borne in mind. There may be failure of normal fusion of ossific centres, or there may be abnormal fusion, as between the atlas and the occiput or between the atlas and axis (Figs. 5 and 6). The variations that occur may be compared with those that affect the lumbo-sarcal region. Thus the term " occipitalisation of the atlas " has been coined and the idea of " cervical axial spondylolisthesis " (Kahn and Yglesias 1935) as a factor predisposing to injury has been presented. Special radiographic techniques—tomography, stereoscopic views, and the use of contrast media—may be necessary in investigating these cases.

CLASSIFICATION OF INJURIES OF THE ATLAS AND AXIS

The following classification is based on those of Corner (1907), Sullivan (1949), and Cone and Turner (1937).

Fractures without dislocation.

Atlas.

Axis.

Dislocation without fracture.

Fracture-dislocations.

Forward (unilateral or bilateral).

Backward.

ISOLATED FRACTURE OF THE ATLAS

The mechanism of this injury was described by Jefferson (1920), who reviewed twenty-one cases together with a further twenty-five cases complicated by other injuries of the cervical

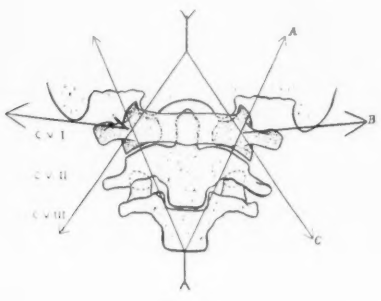

FIG. 7

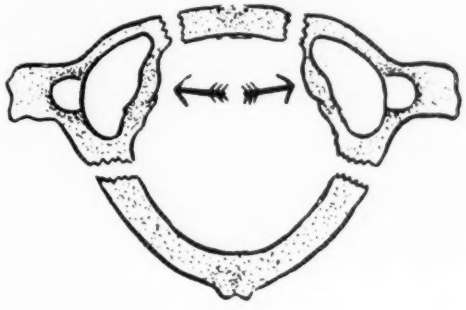

FIG. 8

Figure 7—Jefferson's diagram illustrating the disrupting forces acting upon the atlas. Figure 8—Atlas viewed from above to show the result of "spreading," the bony arch yielding at its weak points (Jefferson).

spine. According to Jefferson, isolated fractures of the atlas usually result from indirect violence from impact of the head on the ground. The violence is transmitted through the occipital condyles to the atlas and meets opposing forces transmitted by the spine to the axis vertebra. In consequence of the sloping articular surfaces of the lateral atlanto-axial

joints there is a disrupting tension on the atlas ring (Fig. 7). The weakest points of the ring are in the anterior and posterior arches (Fig. 8). Fracture of the thick lateral mass occurs only when the head is flexed to one side at the time of the injury, so that considerable force is transmitted through it. In Jefferson's series the fracture involved the posterior arch in twenty-five cases, the anterior arch in seventeen, and the lateral mass in seven. The spinal

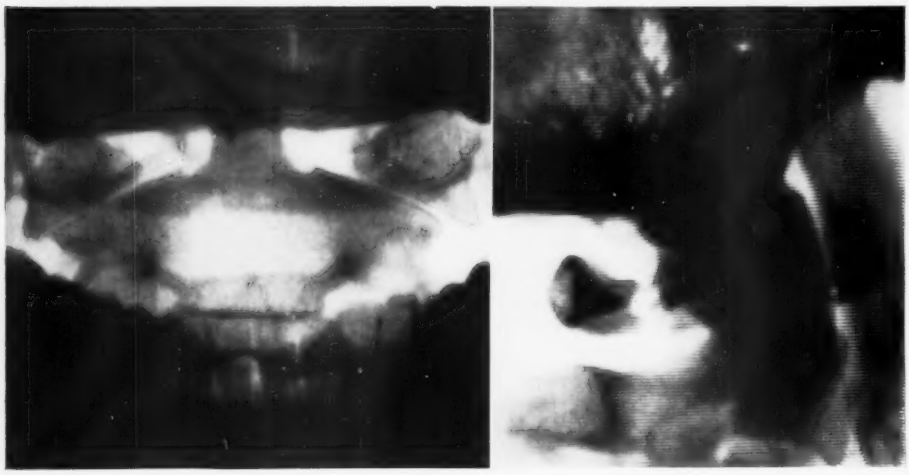

FIG. 9

Case 1—Isolated fracture of the atlas. Note in the antero-posterior view the displacement of the articular facets.

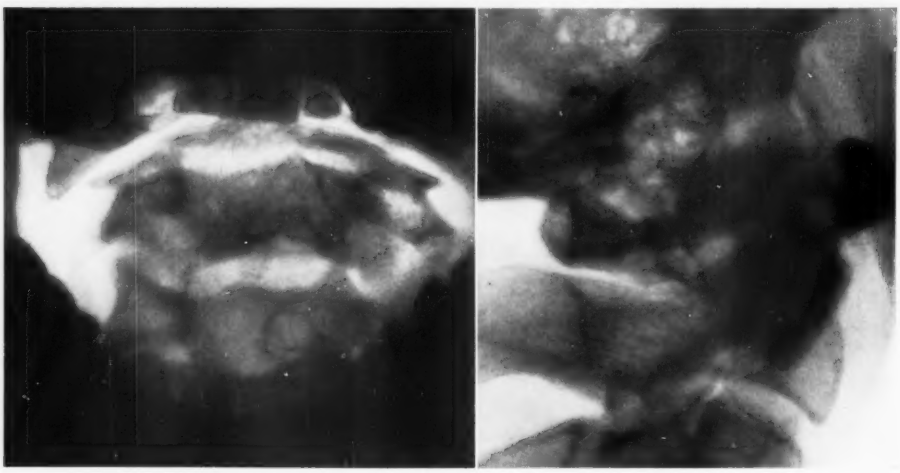

FIG. 10

Case 1—Three months after injury. The displacement of the facets remains but the laminae have united.

cord was injured in nineteen of the forty-six cases; but in most of these the fracture of the atlas was associated with other injuries of the cervical spinal column. Injury to the greater occipital nerve is to be expected with fractures of the posterior arch.

CASE REPORT

Case 1—A man of twenty-one collided head-on with another player during a game of rugby football. Despite pain in his neck he continued playing. He walked to the hospital holding his

head with his hands. Examination showed local tenderness over the upper cervical spine and limitation of rotation. No neurological abnormality was detected in the central nervous system. Radiographs showed fractures of the anterior and posterior arches of the atlas (Fig. 9). After two days' rest in bed a plaster collar was applied and a week later he was allowed up. The plaster was retained for three months. Radiographs after its removal showed that the fractures were uniting, but the atlas ring remained enlarged (Fig. 10).

ISOLATED FRACTURE OF THE ATLAS

No case of isolated fracture of the axis was encountered in this series.

SPONTANEOUS DISLOCATION OF THE ATLAS AND AXIS

Sullivan (1949) reviewed fifty-two cases from the literature and reported four further cases. He recognised anterior displacement on one or both sides, and posterior displacement. The average age of the patients was thirteen years. Most cases occurred in association with inflammatory lesions in the neck, including rheumatic fever, cervical gland infection, pharyngitis, retropharyngeal abscess, influenza, rheumatoid arthritis, and tonsillectomy. A case of voluntary displacement by which the owner gained a livelihood has been described (Brav 1936). A case is also recorded of dislocation in a newborn infant after difficult delivery (Lounavaara 1949).

Clinical features—Sullivan emphasised the clinical appearance. *Unilateral anterior displacement*—The head is rotated away from the affected side and tilted towards it. It is flexed forwards so that the mouth cannot always be opened to examine the naso-pharynx. The voice may have a nasal quality, from closure of the naso-pharynx by the displaced atlas bulging into the posterior wall (Hess *et al.* 1935). There is tenderness over the spinous processes of the atlas and axis and the axis may be rotated away from the affected side (Sudeck's sign). Compensatory cervical scoliosis may be present. Root and cord signs are infrequent. *Bilateral anterior displacement*—There is little rotation of the neck; the head is tilted forwards, movement in all directions is limited, and the pharyngeal bulge is prominent. Signs of compression of the spinal cord are more likely. *Unilateral posterior displacement*—The neck is rotated towards the affected side and extended. The spinous process of the axis is also rotated towards this side but no pharyngeal bulge is present.

CASE REPORTS

Case 2—A boy aged four years complained of neck stiffness, first noticed one week after tonsillectomy. He lay on his face with the neck flexed and the head buried in a pillow. There was pyrexia of 101 degrees Fahrenheit, with cervical adenitis, but no abnormal neurological signs were detected. Radiography showed forward subluxation of the atlas on the axis and retropharyngeal abscess (Fig. 11). The displacement was reduced and a plaster jacket applied (Fig. 12). His condition remained satisfactory for ten days, but thereafter he developed renewed pyrexia and became drowsy. Neurological examination showed an extensor plantar response on both sides, with brisk tendon reflexes and urinary incontinence. Radiographs showed that subluxation had recurred (Fig. 13). Lumbar puncture showed 300 leucocytes per cubic millimetre, but culture was sterile.

The plaster was removed, the dislocation was again reduced, and operative fusion of atlas and axis by wiring and cancellous chip grafts was undertaken. The functional result one year after operation was excellent (Fig. 14).

Case 3—A girl aged ten years complained of stiff neck which developed a week after an attack of sore throat. On examination some facial asymmetry was noticed. The head was rotated to the left and flexed to the right. The upper cervical spinous processes were prominent and tender. There were no neurological signs. Radiographs showed anterior dislocation of the atlas on the axis (Fig. 15). The dislocation was reduced but subluxation recurred on several occasions despite immobilisation in plaster.

Operation—The displacement was reduced and atlanto-axial fusion was undertaken by cancellous bone grafts with wire fixation. Radiographs three months later showed satisfactory fusion (Fig. 16).

DISCUSSION

Mechanism of displacement—The association of inflammatory processes with atlanto-axial subluxation has been recognised since 1830, when Bell described a case. Opinions differ on

FIG. 11

FIG. 12

Case 2. Figure 11—Spontaneous anterior subluxation of the atlas on the axis, before reduction. Figure 12—After reduction.

FIG. 13

FIG. 14

Case 2. Figure 13—Recurrent subluxation in plaster. Figure 14—one year after fusion by cancellous bone chips and wire fixation.

the way in which the inflammatory changes lead to displacement. Sullivan (1949) quoted various reported hypotheses. Watson Jones (1932) noted the association of decalcification of

the anterior arch of the atlas with the spontaneous subluxation which developed in a nine years old boy as a complication of mastoiditis. Recalcification occurred when the infection subsided. Decalcification was also found by Greig (1931) and by Leriche and Policard (1926). Other hypotheses ascribe the displacement to metatastic effusion into the joints (Wittek 1908), a combination of ligamentous laxity and muscle spasm (Hess *et al.* 1935), and excessive rotation of the neck under anaesthesia (Sudeck 1923). In Case 3 of this series the displacement was associated with a large retropharyngeal abscess which probably resulted from infection of a haematoma after tonsillectomy. It seems likely that considerable loosening of the transverse and accessory ligaments occurred. No decalcification of the vertebrae was seen. The case resembles that in the newborn infant described by Lounavaara (1949), in which necropsy confirmed the presence of a large retropharyngeal abscess with laxity of the transverse ligament; but in that case decalcification of the vertebrae was also noted.

FIG. 15

FIG. 16

Case 3. Figure 15—Spontaneous anterior atlanto-axial subluxation. Figure 16—Three months after fusion by cancellous bone chips and wire fixation.

In Case 2 there was a definite history of sore throat, but this had almost subsided before the dislocation occurred. No retropharyngeal abscess was present, and no evidence of decalcification was observed.

Diagnosis—Clinically, atlanto-axial subluxation may be suspected from a history of upper respiratory or cervical gland infection and sudden onset of a stiff neck, with the clinical signs enumerated. *Radiographically* the shape of the space between the anterior arch of the atlas and the odontoid process is significant. If the spinous process of the atlas is displaced forwards in relation to that of the axis, this is further evidence of a dislocation. In the antero-posterior view there may be asymmetry of the articular facets in unilateral dislocation. In doubtful cases stereoscopic views and special techniques may be required.

Treatment—The risk of atlanto-axial subluxation should be borne in mind in cases of infection in the upper cervical region, and energetic treatment with antibiotics should be begun immediately.

Reduction—Walton's manoeuvre (1893) is often successful. In Case 3 reduction was obtained simply by resting the patient's shoulders on a pillow and allowing the head to extend. When traction is required a halter may be used but unless it is carefully applied it is likely to lead

to pressure sores. Skeletal traction is more satisfactory; it may be maintained for a longer period and it is more comfortable (Cone and Turner 1937).

Maintenance of reduction—It is clear from the two cases described that displacement is liable to recur. Prolonged skeletal traction would possibly have been sufficient to allow stability to be attained. Nevertheless if displacement recurs despite immobilisation in plaster operative fusion should be undertaken. Fusion should be limited to the atlas and axis; in the cases described it was obtained by wiring the posterior arch of the atlas to the spinous process of the axis with the addition of a cancellous bone graft.

UNCOMPLICATED ANTERIOR FRACTURE-DISLOCATIONS

In fracture-dislocations there may be anterior displacement on one or both sides, or posterior displacement.

Review of previous reports—Walton (1903) gave one of the first clear descriptions of this type of injury. He noted that it was seldom fatal, and that the dislocation was usually unilateral. He described a rational method of reduction: the head was first flexed and rotated in the direction of the deformity; then it was rotated back to the mid-line.

Corner (1907) described the clinical appearance and anatomical basis of the injury. He emphasised that stability is largely dependent on the protective action of muscles. If this is absent, as in sudden unexpected violence or a strain during anaesthesia, conditions are favourable for rotatory dislocation of the atlas and fracture of the odontoid process. Corner reviewed twenty cases, of which eight were fatal. Only two of the deaths occurred soon after the accident. The most graphic account of delayed death after an injury of this type was recorded by Gibson (1885). His patient was a man of fifty-eight who had rolled down a bank and lay there all night. Being too unsteady to walk unaided, he was assisted home. His head was flexed forwards so that his chin rested on his sternum. There was a prominence of the cervical spine below the occiput. There was no paralysis, but he could not swallow. He was put to bed and steady traction was applied to the head. The dislocation reduced with a snap and crepitus was heard. He lay in bed with his head between sandbags. On the twenty-third day he sat up to eat some food, complained of abdominal pain, and dropped dead. At post-mortem there was marked separation of the spinous processes of the atlas and axis. The spinal cord was stretched tightly over the anterior surface of the spinal canal, and it was indented by the jagged edge of the body of the axis, where the odontoid had been broken. The odontoid process remained attached to the anterior arch of the atlas. There was no gross damage to the spinal cord. Other cases of delayed death were reported by Cortes (1907), Bernstein (1903) and Lambotte (1894).

Of the ten non-fatal cases recorded by Corner spinal symptoms were present only in one. Corner stated that only one patient had a fracture of the odontoid, but perhaps modern radiology would have revealed more. Corner described the characteristic position of the head in this injury. It is flexed and turned to one side. The side to which the chin is directed is that on which the transverse process of the axis is rotated backwards. The spine of the axis is rotated towards the side from which the head is bent. Sometimes this spinous process is abnormally prominent, denoting marked forward displacement of the head associated with a fracture of the odontoid process. Examination of the pharynx reveals two prominences. One is due to the forwardly displaced transverse process; the other is formed by part of the axis which has been made prominent by backward displacement of the transverse process on that side. He emphasised the increased danger if the odontoid is fractured; of the eight fatal cases coming to necropsy it was broken in six, whereas of the ten cases that recovered there was evidence of a fracture in only one.

Mixter and Osgood (1910) emphasised that redislocation and "myelitis" from late injury to the cord may occur. They described the case of a boy of one year who fell from a tree, striking his head. There was immediate pain and stiffness. Five weeks later signs were

still present. Prominence of the cervical spines and a pharyngeal bulge suggested dislocation despite inconclusive radiographs. There was no evidence of injury to the spinal cord. The neck was manipulated by Walton's manoeuvre, and flexibility of the spine returned. The boy returned home against advice. Six months after the accident severe occipital neuralgia occurred, and a second manipulation again restored movement of the neck, and apparently reduced the dislocation. In spite of protection in a plaster collar for a month, followed by a leather Thomas's collar, symptoms returned. A lateral radiograph then showed a fracture of the odontoid process and forward dislocation of the atlas. Traction was applied to the head, and open reduction was undertaken and the posterior arch of the atlas was secured to the spinous process of the axis by silk sutures. A leather cuirass was worn for two months. Recovery was uneventful.

Cone and Turner (1937) also noted the usual absence of spinal cord symptoms after injuries in this region; they recognised the possibility of sudden death or later paralysis if

FIG. 17

FIG. 18

Case 4. Figure 17—Fracture-dislocation of the atlas upon the axis. Figure 18—Position immediately after reduction.

the injury is not recognised and treated. They quoted the case of a doctor who dislocated his atlas while attempting a forceps delivery. Sixteen years earlier he had sustained multiple injuries in a car accident and had been unconscious for two or three days. Thereafter his neck was stiff but he continued general practice. When the forceps slipped his head was jerked forwards and he noticed sudden numbness and tingling in the fingers and weakness of the arms and legs. The neck was rigidly splinted by muscle spasm. Reflexes were present, but there was a bilateral plantar extensor response. There were no sensory changes apart from paraesthesiae of the hands. Lumbar puncture showed a complete block. Radiographs showed anterior dislocation of the atlas on the axis. Operative reduction and decompressive laminectomy were performed. The cord was found to be pressed on by the posterior arch of the atlas. Subsequent wiring and fusion of the upper six cervical vertebrae produced satisfactory recovery though considerable limitation of rotation of his neck was present.

Cone and Turner considered that skeletal traction is of great assistance in reducing these

FIG. 19

Case 5—Fracture-dislocation of the atlas upon the axis in an elderly patient. Marked osteoarthritic changes were also present.

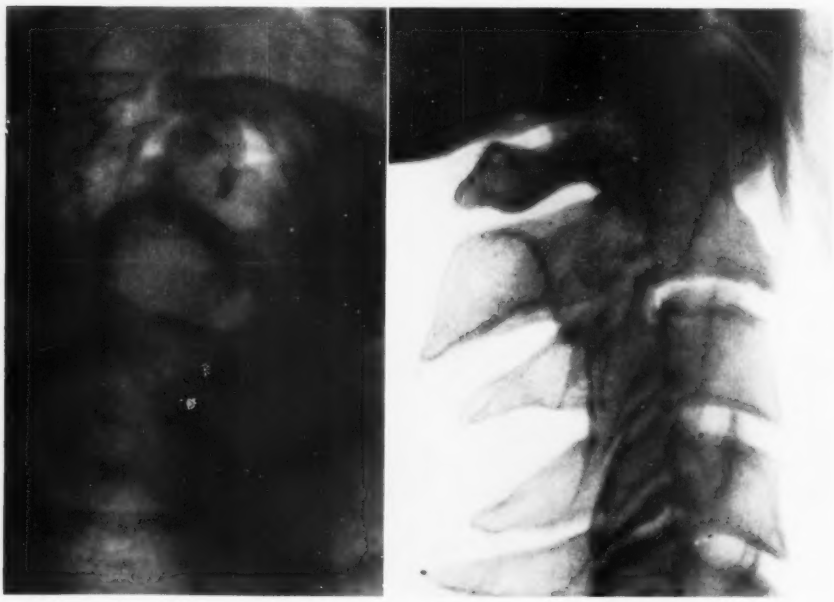

FIG. 20

Case 6—Old fracture-dislocation of the atlas upon the axis. The special projection (*left*) recommended by Cone and Turner shows an ununited fracture of the anterior arch of the atlas and displacement of the odontoid process.

dislocations and in maintaining reduction. They advised operative fusion in cases of multiple fractures, fracture of the odontoid, recurrent displacement, or evidence of spinal cord injury.

Colsen (1949) also described fracture-dislocation of the atlas on the axis after manipulation of the neck under an anaesthetic. There were no abnormal neurological signs, but paraesthesiae of the forearms and hands were present. The dislocation was reduced by skeletal traction and the upper four cervical vertebrae were fused with satisfactory result.

CASE REPORTS

Three cases of forward dislocation of the atlas on the axis are presented to demonstrate some of the features of these injuries.

Case 4—A man of seventeen sustained a head injury while riding a motor cycle. The initial radiographs showed no fracture of the skull, and the atlas and axis retained their normal relationships. He was discharged from hospital after six days. Nine weeks later he was again involved in a motor cycle accident and was admitted to hospital. There was a bruise over the right zygoma, with marked tenderness over the spinous process of the second cervical vertebra. There were no neurological signs. Radiographs showed a fracture-dislocation of the atlas on the axis (Fig. 17). The displacement was reduced by manipulation (Fig. 18) and a plaster jacket was applied.

Case 5—A woman of seventy-nine fell downstairs, striking her head. There was no loss of consciousness but she noticed severe pain in the neck and chest. She was admitted to hospital four days later. There was no sensory or motor disturbance but any movement caused severe pain in the neck. There was marked limitation of all head and neck movements. Radiographs showed fracture of the odontoid process with forward subluxation of the atlas on the axis (Fig. 19). A plaster collar was applied. This had to be removed two days later because she would not tolerate it and said it was unnecessary. Her continued improvement substantiated these remarks. Three weeks later she began to sit up and was discharged after one month to a convalescent home wearing a plastic collar. One year later she wrote that she was leading an active life, had little discomfort and found the collar unnecessary.

Case 6—Another example of this type of case emphasises that complete reduction is not always necessary for a good functional result, though a prolonged convalescence may be needed before the patient returns to work. Figure 20 shows the appearance ten years after a dislocation of the atlas on the axis. This had been treated by attempted manipulative reduction and immobilisation in plaster. There were associated fractures of the third and sixth cervical vertebrae. The neck was stiff and painful for nearly two years, but eventually the patient returned to work as a roundsman. The radiograph shows an ununited fracture of the arch of the atlas. The projection is that recommended by Cone and Turner, and it is noteworthy that radiographs taken a year after the injury had failed to show these later findings.

UNCOMPLICATED POSTERIOR FRACTURE-DISLOCATION

Posterior fracture-dislocations are caused by hyperextension injuries and are less common than anterior displacements. Among those described is one by Cone and Turner (1937). A notable feature of their case was the marked hyperaesthesia in the second and third cervical dermatomes, so that the child screamed with pain by the lightest current of air striking his chin or upper neck. There were also loss of pain and temperature sensation in the right arm, and bilateral extensor plantar responses. The dislocation was reduced by skeletal traction and operative fusion was carried out.

CASE REPORT

Case 7—A woman of sixty-nine sustained a hyperextension injury of the neck in a motor accident. There was no spinal cord injury. Radiographs showed a comminuted fracture with posterior dislocation (Fig. 21). She was treated by immobilisation in plaster for eight weeks, and thereafter with a plastic collar. The functional result was satisfactory.

FRACTURE-DISLOCATIONS COMPLICATED BY SPINAL CORD INJURY

Fracture-dislocations complicated by spinal cord injury are caused by a more severe type of injury. In some cases the cord damage is due to associated fractures of other cervical vertebrae, no damage occurring at the level of the atlanto-axial articulation. Many patients with these injuries never reach a hospital alive; consequently the relative incidence of uncomplicated and complicated cases is difficult to assess. As already stated, signs of cord injury

FIG. 21

Case 7—Posterior fracture-dislocation of atlas upon axis caused by a hyperextension injury.

may be present immediately, or they may result from later displacement. The cord lesion may consist in compression, haematomyelia, or vascular disturbance. Recovery after reduction of the dislocation has been described (Cone and Turner) and it may also occur despite failure to reduce the displacement (Pilcher 1910).

The neurological changes have not always been closely correlated with the mechanism of a particular injury. It seems, however, that in cases of incomplete cord injury the following are the commonest features: 1) motor weakness or complete paralysis of the arms and legs; 2) exaggerated reflexes, with extensor plantar response; 3) paralysis of bladder with retention of urine; 4) impairment of pain and temperature sense (hyperextension injury, Cone and Turner 1937); 5) nerve root lesions with hyperaesthesia in the area of C.1 and 2 and occipital neuralgia; 6) paraesthesia and hyperaesthesia of hands and fingers. It appears, therefore, that the damage to the spinal cord may be most marked anteriorly. Injury to the spino-thalamic tract sometimes occurs, as in the case of a hyperextension injury described by Cone and Turner (1937). Indentation of the anterior surface of the cord was noted in a necropsy specimen by Gibson (1885), and it has been produced experimentally (Fig. 2). An exception to this generalisation is the case of the doctor described by Cone and Turner; in that case the posterior arch of the atlas was found at operation to be pressing on the spinal cord. Even so, the main neurological features were those of pyramidal and motor disturbance, and posterior column sense was intact. Perhaps the mechanism of injury is similar to that suggested by Kahn (1947) in cervical spondylosis. Anterior compression of the cord results in traction on the denticulate ligaments and damage to the pyramidal tract, whereas the posterior part of the cord remains relatively intact.

Paraesthesia or hyperaesthesia of the hands and fingers, which is said to be a common feature (Cone and Turner 1937), is difficult to explain, except perhaps by associated compression of the cord or nerve roots at a lower level. It is possible that the neurological picture may be caused in part by compression of the anterior spinal artery as described by Dimsdale (1954) in cases of cervical spondylosis. Such a possibility is yet another reason for early and skilful reduction in all cases with neurological manifestations.

CASE REPORT

Case 8—The following case is described to show the type of injury which is likely to be complicated by spinal cord damage. A woman of forty-five was involved in a motor accident which gave her head a severe jolt. A transient quadraplegia occurred, and she was admitted to Addenbrooke's Hospital. Recovery of movement of the legs soon took place, leaving paralysis of the upper limbs and marked hyperaesthesia of the supraclavicular nerves. Radiographs showed a fracture of the pedicles of the axis with forward displacement of the atlas (Fig. 22). Reduction was secured by skull traction (Fig. 23). Traction was continued for six weeks, during which there was gradual improvement in motor power. Some residual weakness of the right upper limb remained. She was discharged from hospital after three months, walking quite well. Three years later there was good recovery, apart from some residual pain and weakness in the right forearm and hand.

FIG. 22

FIG. 23

Case 8. Figure 22—Fracture-dislocation of the axis with displacement of the pedicles, causing transient quadriplegia. Figure 23—After reduction.

Comment—It is interesting to compare this injury with that shown in Figure 24. This is an illustration by Wood-Jones (1913) of the ideal lesion produced in hanging. It is taken from specimens, then present in the Royal College of Surgeons, of criminals who had been hanged in the Rangoon prison. The lesion is very similar to that described in Case 8. Sudden snapping of the pedicles of the axis has resulted in complete transection of the spinal cord. According to Teare (1953) hanging seldom causes fracture-dislocation of the atlas and axis or fracture of the odontoid process, for the injury usually occurs at a lower level. Here there is relatively less space in the spinal canal, so that such an injury is more likely to lead to the desired result.

SUMMARY AND CONCLUSIONS

1. Injuries to the atlas and axis may occur at any age. They are usually not fatal.
2. In children spontaneous rotatory dislocation is the commonest type of lesion. In adults fracture of the odontoid process is more likely.
3. The spinal cord is often undamaged. In some cases complicated by cord damage the neurological disturbance is caused by an associated injury to the lower cervical spine.
4. Spinal cord damage may be immediate or delayed.
5. In cases of incomplete cord lesion there may be recovery of function after reduction of the displacement or without such reduction.
6. Diagnosis rests on the history and physical signs, and radiographic findings. Radiographs of this area require careful interpretation, and special radiographic techniques may be necessary. A normal radiograph does not necessarily exclude the possibility of atlanto-axial injury.
7. Though many patients would survive without treatment the initial discomfort and danger of complications demand

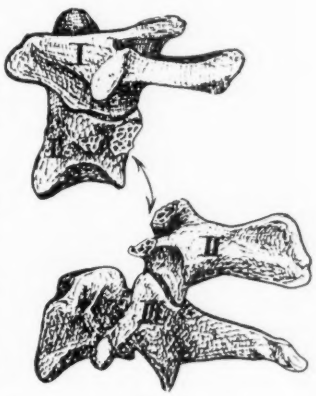

FIG. 24

The lesion present in Captain C. F. Fraser's series of judicial hangings. Separation of the arch of the axis from the body; effect of a submental knot (From Wood Jones). Compare with Figure 22.

that adequate protection be provided. In relatively minor injuries and in old people protection by a plaster collar may be sufficient. In some cases it is justifiable to undertake manipulation and apply a plaster. Cases with severe displacement require traction, preferably by skull calipers. Recurrent displacement, instability, and cord signs demand operative reduction and fusion. Satisfactory fusion of the atlas and axis alone is feasible, and good function is preserved. More extensive fusion of the cervical spine is seldom necessary.

I wish to thank Mr R. Weedon Butler and Mr T. J. Fairbank for permission to describe cases under their care and for their advice. Acknowledgment is also given to the Royal Society of Medicine for permission to publish this report, which is based on a paper read at a meeting of the Orthopaedic Section in November 1953.

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THE USE OF THE ACRYLIC HEAD PROSTHESIS IN HIGH FRACTURES OF THE FEMORAL NECK

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This paper reviews the management and progress of sixty-five cases of high fracture of the femoral neck treated by excision of the head and replacement by an acrylic head prosthesis. The behaviour of the reconstructed hip joints has been studied during the second, third, and, in a few cases, the fourth years after operation, and found to follow a definite general pattern, varying slightly with the anatomy of the fracture.

SELECTION OF CASES

All the patients operated on were over sixty, and three-quarters of them were over sixty-five, the oldest being ninety-three. Many were poor subjects for operation, with cardio-vascular disease, mild urinary sepsis and chronic bronchitis; but if their condition was not rapidly deteriorating this risk was accepted.

Patients with fractures mainly lateral to the mid-point of the neck have been treated by Smith-Petersen nailing, provided that they were reducible; so this series contains only medial fractures and irreducible lateral fractures. Twelve of the series were operated on from one to six months after the fracture, either because of late diagnosis or of failure of a nailing operation. In all other cases the operation was carried out within ten days of the injury. The term " irreducible " is used for fractures in which, after manipulation, uncontrollable rotation of the head is found to have occurred, preventing accurate coaptation of the fractured surfaces.

TECHNIQUE OF OPERATION AND POST-OPERATIVE MANAGEMENT

Originally the lateral Brackett T-shaped incision, detaching either the greater trochanter or the gluteus medius insertion, was used. This was discontinued, however, as being unnecessarily extensive. The Smith-Petersen incision was used in three cases. The usual approach has been through a lateral curved incision, beginning at the anterior superior spine and passing a little behind the greater trochanter, and vertically down the outer side of the thigh. The capsule was exposed anteriorly in the interval between the gluteus medius and tensor fasciae, and incised in a cruciate or T-shaped fashion. It has been found that if the head is removed by this route the gluteus medius must always be partly detached from the trochanter or it will be stretched and damaged by elevators: the damage is not great, but in elderly patients it is probably important.

In ten of the cases reviewed, and in twenty-five other cases in which the operation was too recent to be included in this series, the posterior approach described by Gibson (1950) was used. There is less bleeding and no damage is done to the gluteus medius; the head of the femur lies more superficially in the incision, and is more easily reached. Also the thin posterior capsule of the joint is incised rather than the thick anterior capsule; this has eliminated the tendency to post-operative anterior dislocation that was observed after operations done through the anterior exposure, and which was attributed to the natural lateral rotation of the limb forcing the prosthesis against a fresh scar in the anterior capsule. The stump of the neck has been trimmed to a reasonable smoothness, though in oblique fractures it has sometimes been impossible to secure a flat proximal surface throughout the whole circumference of the neck. It has been noted regularly that the fracture is more comminuted than the radiographs suggest, especially at the inferior margin of the neck.

The drill hole and the stem of the prosthesis have, in every case, perforated the outer

trochanteric cortex, and the aim has been to place the prosthesis in as valgus a position as possible. In some instances, however, the prosthesis has been placed in insufficient valgus.

In all the cases reviewed, except one, the simple head prosthesis has been used rather than the pattern with a neck extension. In six cases liquid acrylic dental cement has been used to fix the prosthesis into the neck and into the channel bored in the greater trochanter—a method suggested by Kiaer (personal communication). No difference in the results has been observed so far in the cases treated by this method.

TABLE I

AVERAGE POST-OPERATIVE PROGRESS IN SIXTY-FIVE CASES

1. Active straight leg raising and abduction in bed	During 3rd–4th week
2. Walking with two sticks	During 4th–5th week
3. Walking with one stick	During 6th–7th week
4. Walking without sticks	Only ten patients achieved this standard

TABLE II

ANALYSIS OF RESULTS

	First year		Second year		Third year		Fourth year	
	Early*	Late	Early	Late	Early	Late	Early	Late
Number of patients studied. . .	53	12	53	12	30 (2 died)	8	10 (3 died)	2
Spontaneous complaint of pain . .	2	1	32	3	28	2	9	1
Gait:								
Slight limp with one stick . .	45	12	28	11	2	8	1	2
Marked limp with one stick . .	8	—	22	1	20	—	4	—
Two sticks and sleeping downstairs .	—	—	3	—	8	—	5	1
Adduction deformity	1	—	15	—	25	—	9	—
Radiographic appearances:								
Progressive shortening of femoral neck since operation	6	1	30	1	24	2	10	1
New bone formation in region of capsule	8	3	35	3	28	6	10	2
Increasingly varus position of prosthesis	1	—	20	1	25	1	10	—

* Early cases = Hips operated upon within a week of injury.
Late cases = Hips operated upon from one and a half to six months after injury.

Post-operative care—Various methods of post-operative treatment have been used, including 1) continuous traction; 2) plaster boot with incorporated transverse bar; 3) bandaging the limbs together; and 4) plaster spica.

Continuous traction—Sliding skin or skeletal traction in abduction was used in fifteen cases. Active movements were encouraged from the second post-operative day. Dislocation of the head of the prosthesis occurred in three patients.

Plaster boot and bar—A plaster boot and bar to maintain medial rotation was used in eight cases. Early active and passive movements were practised. One dislocation occurred.

Bandaging—Bandaging the legs together with a roll of gamgee tissue was tried in ten cases. The method was discontinued because it made nursing difficult and has proved inefficient. Despite the bandage, the sound limb can be abducted, producing adduction and lateral rotation of the affected leg. Three dislocations occurred.

Plaster hip spica—The application of a single well padded hip spica extending to the mid-calf and holding the leg in medial rotation, 20 degrees of abduction and 30 degrees of knee flexion, was used in thirty cases. The spica was retained for two weeks, during which static exercises to all muscle groups were encouraged; it was then bivalved to allow the patient to practise active exercises from the posterior half of the plaster for a further week. This method has been found generally satisfactory, and even the older patients have tolerated the short period of immobilisation well. No dislocation occurred in the thirty cases mentioned (nor in a further twenty not included in this series). Although movement was started relatively later, the immobilisation favoured rapid healing of the soft tissues, and the patients regained their range of hip movement more quickly, and maintained it better, than they did when movements were begun during the first few days. Gentle passive movements are also of value in encouraging active movement, especially during the first two weeks of mobilisation. Weight bearing was allowed when active abduction of the hip was possible, with the unsupported leg actively raised from the bed. This has usually been during the third or fourth week after operation (Table I).

COMPLICATIONS

The immediate post-operative mortality was six (in seventy-two patients=8·2 per cent). Two patients died from myocardial infarction, one from pulmonary embolism, and three from renal failure, during the first week. The early complications noted were urinary sepsis, which occurred to a greater or lesser degree in twenty cases; and venous thrombosis in the leg, which occurred in three cases and delayed recovery. The incidence of serious post-operative chest complications was surprisingly low (4 per cent); all patients received penicillin as a routine for ten days after operation. In seven cases anterior dislocation of the prosthesis, which was reduced by manipulation, occurred during the first two weeks after operation. It was always found necessary to apply a hip spica after the manipulation to prevent redislocation: the reduction was never stable. Dislocation did not occur when the posterior approach with post-operative plaster fixation was used (thirty cases).

RESULTS

Fresh fractures (Table II)—In general, in fresh fractures treated by immediate operation, the clinical results have been as follows. During the first year the hip has been comfortable for weight bearing, and the range of movement has, by the fourth month, reached at least two-thirds of the normal in all directions (Fig. 1). The patient has usually used one stick outside, discarding it in the house, and walking with a slight limp but with little or no pain.

During the second year some minor complaints have been the rule, such as aching in the hip, or a disinclination to go shopping or to climb stairs in the house. During the third year 85 per cent of the patients stated that the hip was painful to a greater or less degree. Limp became more marked and movement diminished to a variable extent. In two patients the prosthesis fractured spontaneously during the first year at the junction of the head and stem. The prostheses were excised and replaced with a corresponding loss of function. In one patient the prosthesis dislocated anteriorly after her return home, but whether this occurred

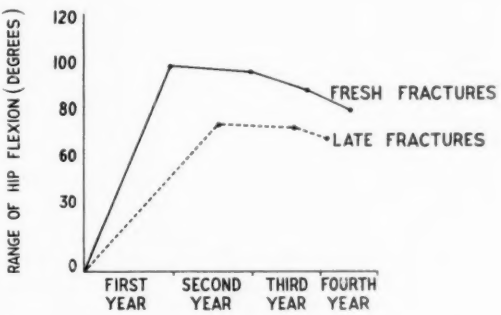

FIG. 1

Average rate of recovery of hip flexion after operation. There was a constant though slight difference between the behaviour of hips operated upon in the first ten days after injury (" fresh fractures ") and those operated upon later than six weeks after injury (" late fractures ").

early or late is not known, for she was mildly demented, and the displacement was not discovered until she was admitted urgently to hospital two years after the hip operation.

Old fractures (Table II)—In the small group of old fractures (twelve cases) operated upon late as a secondary procedure, the range of movement has been slower to recover (Fig. 1), but hip function, once regained, has been maintained a little better (Figs. 2 and 3).

FIG. 2

FIG. 3

Case 1. Figure 2—Non-union after fracture treated by fixation with bone peg. Arthroplasty was carried out eight months later. Figure 3—Eighteen months after arthroplasty. The neck has not shortened and function is still improving.

DISCUSSION

The technique, complications, and results of hip arthroplasty, using the acrylic prosthesis, have been fully described by Judet and Judet (1950, 1952) and by McAusland (1951). Buxton and Waugh (1953) described their experiences with the method applied to 100 cases of mixed etiology. Vaughan-Jackson (1953) and Le Vay (1953) each reported a series of cases of fresh fracture treated by immediate arthroplasty and observed for up to two years.

It seems from this study that acrylic prosthetic arthroplasty has definite limitations in the treatment of fresh fractures of the femoral neck. The hip function after operation has been sustained a little better in cases operated upon late than in those operated upon immediately, but in both groups a decline in the efficiency of the joint has been the rule. By the third year the neck has become absorbed and shortened to a variable extent in 79 per cent of cases, and the hip has become painful (Figs. 4 to 6).

New bone formation has been a common feature, occurring in the capsular attachments to the acetabular margins and the trochanteric region, and sometimes in the gluteal insertion. It was present in 72 per cent of cases by the second year, and in 92 per cent in the third year.

The alignment of the prosthesis has seldom remained constant. By the second year 36 per cent of cases showed an increase in varus position (Fig. 7), which rose to 80 per cent in the third year; the ten cases in their fourth year all showed gradual varus alteration. Two patients developed acute painful episodes in their first year, due to a small fracture of the neck stump, with resultant varus deformity of the prosthesis.

A study of the eight patients with reasonable function persisting into the third year shows that some new bone formation has occurred in the capsule. The shortening of the neck has been minimal, and, in particular, the inferior border of the neck and the upper part

FIG. 4

Case 2—Two and a half years after arthroplasty. The neck has absorbed and the patient is limping with two sticks. At operation the stump seemed satisfactory.

FIG. 5

FIG. 6

Case 3. Figure 5—Immediate arthroplasty was carried out. The stump of the neck was intact. Figure 6—Two years later. The neck has absorbed and the patient is limping with two sticks.

FIG. 7

Case 4—Two years after primary arthroplasty. The infero-lateral part of the neck was intact at operation. Note migration of stem into varus position. A little shortening has occurred and the hip is becoming painful.

FIG. 8

FIG. 9

Case 5. Figure 8—Immediate arthroplasty for fracture. The stump of the neck was intact and long at operation. Figure 9—Two years later. Function still good and no shortening of neck. Walking well with one stick.

of the calcar have remained intact (Figs. 8 and 9). The bone in this region has evidently become denser and better able to stand the strain of weight bearing. Nevertheless the presence of an intact neck stump seems to be no guarantee of long-term success. Several patients with an apparently satisfactory stump at operation nevertheless developed shortening and varus during the second and third year.

Twelve cases were noted at operation to have either a displaced or undisplaced (and unsuspected) V-shaped fracture of the inferior border of the neck extending into the region of the calcar. The results in these cases were among the poorest. The patients developed pain, rapid shortening of the neck, extensive capsular new bone formation, and adduction deformity; in four cases this was observed after only a few weeks of weight bearing. It is clear that the integrity of this region of the neck is an important factor in prognosis. It is not always possible to diagnose this comminution before operation, but, if it is seen, the experience of the series would suggest that a particularly poor result is likely from immediate arthroplasty, especially if early weight bearing is allowed.

In view of the gradual clinical and radiological deterioration that has been observed in the second, third, and fourth years, it seems that in most cases acrylic substitution as a primary operative treatment for this injury cannot be relied upon regularly to give a satisfactory hip, even in elderly patients who are unlikely to make great demands on it.

SUMMARY

1. Sixty-five cases of medial fracture of the femoral neck treated by substitution of the head by an acrylic prosthesis have been studied.

2. In general, the long-term clinical results of prosthetic arthroplasty after fresh fractures have been disappointing. The method has given slightly better results in the treatment of old fractures.

3. In view of the almost perfect results obtained after successful Smith-Petersen nailing in the presence of an adequate blood supply to the femoral head, it seems unjustifiable to abandon this principle for immediate substitution with an acrylic femoral head. Nevertheless it is believed that an arthroplasty of this type is justified in fractures seen late, and in fresh subcapital fractures when the fracture is irreducible. If a prosthesis is to be used, more protection for the stump of the neck against the strain of weight bearing is essential; a simple head prosthesis is inadequate, and a head with either a neck extension or an intramedullary prolongation may give better results.

I am very grateful to Mr D. Ll. Griffiths for permission to report fourteen of these cases, and to Mr John Charnley for his invaluable help and advice. I should also like to thank Sir Harry Platt for his encouragement, and Mr Stanley Brentnall who has been kind enough to read the manuscript. The x-ray photographs were produced by the Department of Medical Photography, Wythenshawe Hospital.

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TRAUMATIC HAEMATOMYELIA FROM RUPTURE OF INTRAMEDULLARY ANGIOMA

Report of a Case

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Twice in this Journal communications have been published of injuries to the neck causing cervical cord damage in the absence of vertebral fracture or dislocation (Taylor and Blackwood 1948, Taylor 1951), and such lesions are convincingly ascribed to changes in the vertebral column during hyperextension. Barnes (1948) showed that hyperflexion of the neck can cause cord compression only if it is sufficient to dislocate and lock the articular processes. The present report is of a quadriplegia that followed flexion exercises of the neck after a latent period of two days; it took the form of a progressive spinal compression, clearly indicating haemorrhage as the compressing agent—provisionally, but wrongly, diagnosed as extradural. Haematomyelia has frequently been reported from specific local injury without ostensible trauma of the spinal column, the mechanical explanation being a shock that is transmitted to an incompressible column of fluid in the delicate elastic cord, the grey matter of which receives meagre support from the surrounding tissue. Records of the effect of trivial violence on a congenital vascular anomaly in the spinal cord do not appear to be readily accessible, but its occurrence, which must be rare, is nevertheless of clinical account.

CASE REPORT

The patient was a tall, thin girl aged ten years and considerably below average weight for her age and height. The history of past illnesses consisted of severe burns of the chest, associated with pneumonia, at the age of one year, and glandular fever at the age of nine. Her tonsils and adenoids had been removed when she was nine. She was admitted to hospital suffering from a progressive quadriplegia.

Two days before, while at school and feeling quite fit and well, she was doing gymnastic exercises. With the rest of the class she placed her head between her legs and turned a forward somersault several times without any apparent untoward effect. About an hour later, during lessons, she complained of slight aching in the back of her neck but she completed her lessons for the day, walked home and ate a good tea. She had a disturbed night and complained of a stiff neck. She attended school all the next day, but at her mother's request was excused from physical training because of a stiff neck. Again she had a restless night but got up on the following morning and wanted to go to school, but was prevented by her mother, who sent for the doctor. When he arrived the patient was up and dressed, came to the door to greet him, and complained only of a stiff neck. He could detect no definite constitutional upset in the girl, found only slight stiffness of the neck, and made a provisional diagnosis of early poliomyelitis. Relying more on the mother's intuition that her child was " not right " than on clinical signs he had her put to bed for observation. He was again called in the afternoon of the same day because of the sudden onset of severe pain in the neck and shoulders, and he then found that the patient was pale, with a weak pulse, and had complete flaccid paralysis of both legs and much weakness of the upper limbs. An hour later there was complete flaccid quadriplegia with complete anaesthesia up to the level of the distribution of the sixth cervical nerves, but voluntary control of the diaphragm was still present. This state was unchanged at the time of her admission to hospital and until a cervical laminectomy was begun at about midnight.

Operation—The exposure of the cervical vertebrae was centred on the fifth, and the laminae of this and of each vertebra above and below were removed. The dura mater thus exposed was tense and did not pulsate. When the dura was incised the spinal cord remained pulseless and there was no extradural or subarachnoid haemorrhage. Within a few minutes, without

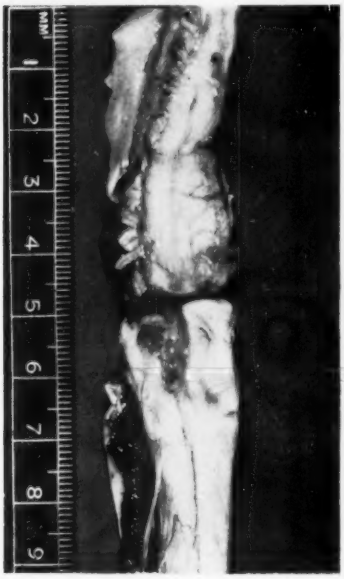

FIG. 1

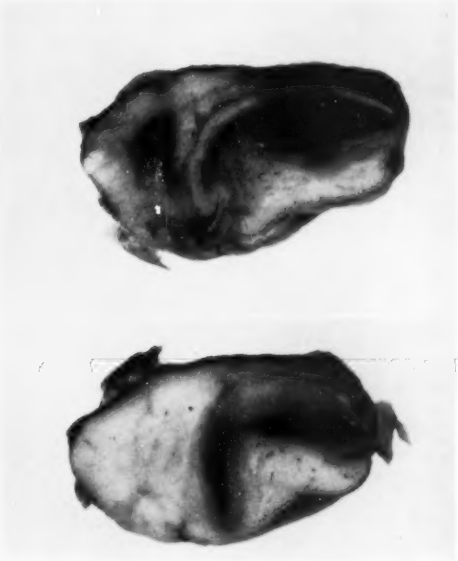

FIG. 2

Figure 1—Cervical spinal cord severed through fusiform swelling, showing blood clot in subdural space on the right antero-lateral surface of the lower cervical and upper thoracic regions. Figure 2—Sections through the aneurysmal dilation of the spinal cord.

any further incision, a severe haemorrhage issued from the upper end of the visible part of the spinal cord and, with the relief of intramedullary tension, the spinal cord began to pulsate. About a pint of blood was lost but the volume was being replaced all the time by a transfusion. After the haemorrhage had ceased the wound was closed, but the patient died a few minutes after the operation ended.

Necropsy—No abnormality was found except a pronounced swelling and softening of the lower cervical region of the spinal cord over a distance of 5·5 centimetres. There was no evidence of fracture, subluxation or dislocation of any of the cervical vertebrae and there was no prolapse or alteration of any of the cervical intervertebral discs. On the front of the cervical column there was a small area of blood-staining at the level of the bodies of the fifth and sixth vertebrae where the blood issuing from the spinal cord had impinged, but there was no evidence of any intrinsic lesion here. The spinal cord was fixed and severed horizontally through the middle of a fusiform swelling, flattened slightly from before backwards, 4·5 centimetres long, in the lower cervical region (Fig. 1). A column of firm, red, unorganised blood clot lay in the subdural space on the right lateral surface of the lower cervical and upper thoracic regions of the cord. The blood appeared to issue from a tear in the right lateral surface of the upper half of the swelling. The severed ends of the cervical cord were soft and irregular, and in horizontal section measured 1·9 centimetres from side to side and 0·7 centimetres antero-posteriorly. In the upper half of the fusiform swelling the overlying leptomeninges were healthy. The swollen cord was soft and semi-fluctuant and on section

there was a recent haematomyelia, destroying the central portion of the cord, and extending upwards for 5 centimetres, gradually tapering but still visible in the first cervical segment (Fig. 2). The lower half of the fusiform swelling was by contrast unduly firm, and on its ventral surface was a small vascular anomaly in the leptomeninges. This was 1·4 centimetres

FIG. 3
Microscopical section of the aneurysmal dilation of the spinal cord.

long (its long axis being parallel to the long axis of the cord) and consisted of two or three thin-walled vessels lying side by side, concealing the ventral fissure and anastomosing freely with one another and with a small round plaque (0·4 centimetres in diameter) of minute tangled vessels situated a little more laterally on the front of the cord. On section the centre

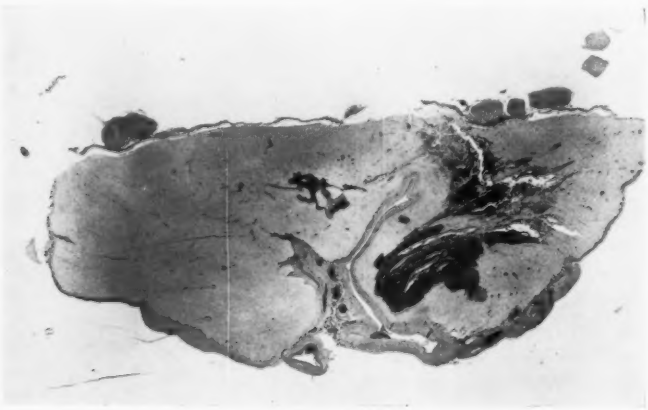

FIG. 4
Microscopical section of the angioma and vessels within the substance of the cord and in the leptomeninges on its anterior aspect.

of the swollen cord was seen to be replaced by an irregular V-shaped mass (apex forwards) of tough, pale, grey fibrous tissue containing several small vascular channels, which communicated with the leash of vessels in the meninges and with a single large cavity filled with blood clot occupying the left half of the lower cervical cord. The cavity measured

1·5 centimetres from above downwards and was semilunar in cross-section, the convexity being directed backwards. Dorsally it was separated from the surface of the cord by a thin rim of compressed white matter (the remains of the left posterior columns); anteriorly portions of grey and white matter lay in its concavity. No abnormalities were detected in the sections made at lower levels.

Microscopy—Sections from various levels through the lesion in the lower cervical cord showed an extensive vascular anomaly, composed partly of arteries but principally of veins, associated with a large haematomyelia. The greater part of the anomaly appeared to comprise a single large venous aneurysmal dilation lying in the long axis of the cord and within its substance (Fig. 3). The lesion seemed to be venous, and communicated with a large vein—presumably the parent vessel—in the subarachnoid space on the front of the cord in the anterior median fissure. Caudally the varix was well developed, but cranially the wall became thinner and was eventually lost in an extensive haemorrhage which had destroyed the central part of

FIG. 5
Field from Figure 4 in higher magnification, showing artery, veins and infiltrating polymorphs.

the cord and ruptured laterally into the meninges. The only evidence of any vascular anomaly in the leptomeninges was a group of small vessels on each lateral surface of the cord; some of these vessels were veins, others arterioles and the remainder small, thin-walled cavernous channels. In the section (Fig. 4) taken from below the point of severance of the cord the angioma was well seen; in addition to the vascular channels, there were numerous vessels—mainly venous but including at least two arteries (one very large and lying in the anterior median fissure), both within the substance of the cord and in the leptomeninges on the front of the cord. Polymorphonuclear cells had infiltrated the walls of some of the larger vessels and were also present in the adjacent nervous tissue and meninges. A narrow zone of polymorphs was seen beneath the intima of a segment of the wall of the varix (Fig. 5). Above the point of severance the cord was largely destroyed by haemorrhage and recent softening, although the degree of damage diminished at higher levels. Below the point of severance the haemorrhage quickly tapered away, but the angioma extended to approximately C.8 or T.1. The angioma, consisting here of the varix, occupied more than half of the horizontal

area of the cord; it lay mainly to the left of the midline, had displaced the central canal to the opposite side, and had distorted the anterior grey columns. Anteriorly and medially the varix was surrounded by compressed nervous tissue, but posteriorly and laterally it was immediately subjacent to the meninges except, in places, for a narrow zone of compressed white matter which was all that remained of the posterior and lateral columns.

COMMENT

The thinness of the walls of the angioma in some places, in others the thickness and rigidity caused by calcification, and the general lack of muscular and elastic tissue in the vessels comprising the tumour, would predispose to rupture. The presumed slight injury sustained during flexion exercises of the neck appears to have been enough to induce rupture of the tumour, either directly or after thrombosis and softening of the surrounding tissues. The second mechanism might explain the latent period between the injury and the appearance of spinal compression, but the histological evidence is insufficient to support it. It is remarkable that such a vulnerable anomaly could have existed for so many years without giving any clinical hint of its presence even after the manipulation of the neck under anaesthesia in 1951 which must have taken place when the tonsils and adenoids were removed.

I am greatly indebted to Dr A. J. F. Maloney, Lecturer in Neuropathology, University of Leeds, for the microscopy and to Dr J. Walker Hirst for the early clinical details.

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FRACTURES OF THE SURGICAL NECK OF THE HUMERUS

A Study in Reduction

T. B. WHISTON, FALKIRK, STIRLINGSHIRE, SCOTLAND

Fractures of the surgical neck of the humerus are commonly grouped into adduction and abduction types, each the product of a definite mechanism, and each presenting a characteristic radiographic pattern. This simplifying of former modes of classification is advantageous not only in describing the displacement, but also in determining treatment. It is considered that a fall on the outstretched hand and the forcible adduction or abduction of the patient's arm following the moment of impact, according to the movement of the trunk, is the main sequence of events culminating in one or other type of fracture. The abduction variety is probably commoner in adults, whereas in children adduction deformity invariably occurs (Aitken 1936, Watson-Jones 1943).

The ordinary antero-posterior radiographs show the type of fracture, with or without impaction. Appearances in such films, however, can be deceptive, and in order to ascertain the full extent of the deformity, additional views should be taken—namely, the lateral or transaxillary projection with the tube directed into the axilla of the abducted arm and the casette placed above the shoulder. If pain prevents the assumption of this position without anaesthesia, a transthoracic projection similarly will disclose the true nature of the lesion, and complete the radiographic evidence. In six of the seven cases referred to in this article, the fractures were characterised by marked rotation of the humeral head and anterior displacement of the shaft, such deformity being fully demonstrated only in transthoracic views, as the ordinary antero-posterior films gave little or no indication of its existence (Blackett and Healy 1937).

When such a displacement occurs reduction is difficult to achieve, because the surgeon is usually unable to control during manipulation the short, rotated, and abducted humeral head.

SURGICAL ANATOMY

The capsular ligament of the shoulder joint, essentially a cylindrical sleeve, is attached to the anatomical neck of the humerus superiorly, just medial to the greater and lesser tuberosities. It adheres closely to the articular margin, gradually falling away in front and behind, until on the infero-medial aspect it encroaches on the shaft half an inch from the articular surface of the head. The tendons of the supraspinatus superiorly, the infraspinatus and teres minor posteriorly, and the subscapularis anteriorly, although partly separated from the capsule by the subscapular bursa, blend with the ligament near their insertions, strengthening it and during contractions prevent its being nipped between the articular surfaces (Jamieson 1945, Cunningham 1951).

With certain fractures of the surgical neck of the humerus the proximal fragment, consisting of the humeral head, tends to assume an abducted and laterally rotated position from the selective pull of the supraspinatus and infraspinatus muscles; and in addition some degree of flexion results from contraction of the subscapularis. The distal fragment—that is, the shaft of the humerus—tends to be drawn and rotated medially; it is also displaced anteriorly in relation to the head by the action of the powerful muscles inserted into the bicipital groove—namely, the pectoralis major, latissimus dorsi, and teres major. Shortening is usually present.

FIG. 1

FIG. 2

Case 4—Man aged forty-three. Before reduction. Note rotation of humeral head in transthoracic view (Fig. 2).

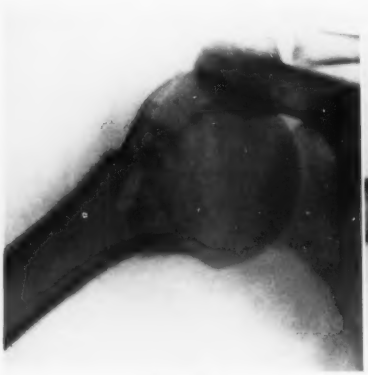

FIG. 3

FIG. 4

Case 4—After reduction.

FIG. 5

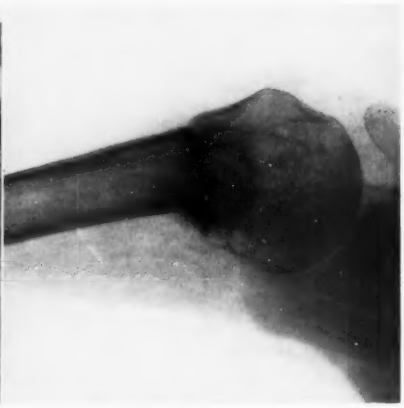

FIG. 6

Case 4—Five months later. Good recovery of function after three months' mobilising exercises.

FIG. 7

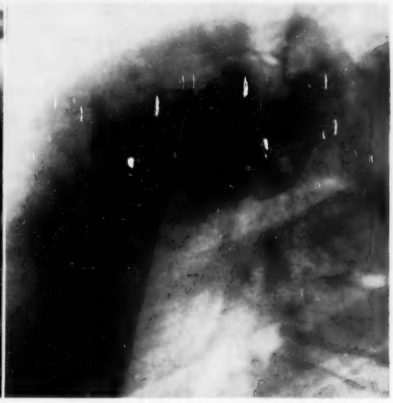

FIG. 8

Case 7—Boy aged thirteen. Before reduction. Note marked rotation of humeral head and anterior displacement of shaft in transthoracic view.

FIG. 9

FIG. 10

Case 7—After reduction.

FIG. 11

FIG. 12

Case 7—Six weeks later. Full range of movements after three weeks' mobilising exercises.

The problem of reduction therefore arises from the relative immobility of the rotated humeral head, fixed by the scapulo-humeral muscles; and should attempts fail to coax the head into normal alignment with the shaft in the adducted position, then manipulation of the shaft into correct alignment with the head would seem logical. Furthermore the lateral rotary movement, imparted to the humerus during abduction by the action of the scapulo-humeral muscles, must be taken into account when manipulation is in progress. Traction on the abducted humerus is not sufficient. In addition it must be rotated laterally to restore the anatomical relationship of the head to the shaft, and incidentally to render the reduction stable (Lockhart 1930, Martin 1940, Cunningham 1951).

TECHNIQUE OF REDUCTION

The patient is anaesthetised and prepared for the application of a shoulder spica. A padded chest-piece is fitted before the manipulation is carried out. Alternatively manipulation may be performed first, the arm held in position, and a padded chest-piece then applied while films are being developed to check the reduction.

If the left humeral surgical neck is involved, the surgeon grasps the patient's left elbow with his left hand, taking the patient's left hand in his right, and flexing the patient's elbow to 90 degrees. He then applies steady and controlled traction to the abducted upper arm, and gently rotates the shaft of the humerus laterally, using the patient's forearm as a lever. Countertraction on the chest wall helps to steady the trunk and increase the pull. Two films, an antero-posterior and a lateral, are taken. It may be necessary to apply manual pressure to the shaft of the humerus to improve the position in one or other plane.

When satisfactory reduction has been obtained a padded arm-piece is completed, fitting closely around the shoulder and well moulded. Whenever possible without disturbing the position of the reduction, the final degree of abduction should be below 90 degrees with the upper arm flexed slightly to approach the plane of the scapula, but moderate lateral rotation must be maintained to ensure the stability of the reduction. Further films are taken and if the position is satisfactory a supporting strut may be added. Sometimes wedging may be required.

After about six weeks the arm-piece is bivalved and, if union is judged to be sufficiently advanced, active abduction and medial rotation exercises are begun. As soon as active abduction above 90 degrees is possible the spica is removed and the arm supported in a sling, with a large pad of wool in the axilla. At first adduction and medial rotation are necessarily limited, but with assiduous exercises rapid improvement in range should occur.

By this technique good reduction has been obtained in each of the seven cases in which it has been used. Illustrative radiographs are shown in Figures 1 to 12.

DISCUSSION

Certain fractures of the surgical neck of the humerus, characterised radiographically by marked rotation of the humeral head and anterior displacement of the shaft, are difficult to reduce. The full extent of the displacement is appreciated only when transthoracic views are taken in addition to antero-posterior films. The humeral head, fixed by the scapulo-humeral muscles in an abducted, laterally rotated, and slightly flexed position, usually resists manipulative attempts to restore normal alignment of the head to the shaft in the adducted position. Accurate reduction, verified radiologically, was obtained by using the technique described above.

It is suggested that in young and active patients exhibiting such fractures with typical gross displacement, in whom accurate reduction is desirable with a view to obtaining good recovery of function, this method should prove effective. A spica skilfully applied in the abducted and laterally rotated position is quite safe, and indeed soon relieves pain at the site of fracture.

I am indebted to Mr A. J. Innes for permission to treat these cases and publish this paper, and to Dr John Park, Medical Superintendent. My thanks are also due to Sister E. Bremner, and to Dr D. M. Harper, Radiologist, and his staff for their invaluable help. I wish to acknowledge gratefully the stimulating interest shown by Professor Walter Mercer and Mr J. N. J. Hartley, and finally the generous advice and help offered by Professor R. Walmsley.

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OSTEOGENIC FIBROMA OF BONE

A Report of Two Cases

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From the Institute of Orthopaedics, Royal National Orthopaedic Hospital

The two cases with which this report is concerned were found during a survey of bone lesions in which a diagnosis of osteoid osteoma had been suggested (Golding 1954). The two cases are remarkably alike, and, although at first sight they appeared to belong to the osteoid osteoma group, on careful study it became evident that they differed from it both clinically and pathologically.

In each case the symptom was paraplegia from cord compression by an expanding lesion originating in the region of the vertebral lamina, the lesions themselves causing little pain.

Fig. 1

Case 1—Radiograph showing erosion of the right lamina and pedicle of the first thoracic vertebra, and a J-shaped area of dense irregular calcification lying in relation to the erosion. The lamina of the seventh cervical vertebra appears abnormally dense.

Permanent recovery followed local excision of the tumours, although in each case radiotherapy was instituted on the erroneous supposition that the lesion was malignant. Histological study of the resected tissue revealed in each case a mixture of osteoid tissue, irregularly calcified non-lamellar bone, and cellular fibrous tissue.

The lesions resemble closely those that Lichtenstein (1952) has called "osteogenic fibroma of bone." Although this entity has not yet been clearly defined, the points that emerge from Lichtenstein's account are as follows. The lesions, which occur in children and young adults, are usually situated in the samll bones of the hands and feet, or in the spine, and appear radiologically as circumscribed rarefying areas, with some scattered calcification or ossification. Although benign, they can sometimes grow rapidly and produce a bulky lesion.

CASE REPORTS

Case 1—A girl aged fourteen years was admitted to the Royal National Orthopaedic Hospital, under the care of Mr H. J. Seddon, complaining of weakness of her legs accompanied by paraesthesiae. The symptoms had begun insidiously six months before as a constant dull interscapular ache. The weakness in the legs appeared two months before admission and had progressed until unaided walking became impossible. On examination she was found to have a

FIG. 2

FIG. 3

Case 1. Figure 2—Tomograph at six centimetres showing the right half of the neural canal occupied by an irregular dense calcified mass. Figure 3—Radiograph one year after completion of treatment. There is a dense sclerotic area in the region of the pedicles and laminae of the seventh cervical and first thoracic vertebrae.

partial paraplegia. There was a well marked sensory level at the first thoracic dermatome, and some tenderness was found to the right of the seventh cervical spinous process. The Wassermann reaction was negative. The Mantoux reaction was positive at 1/100. A lumbar puncture was performed; the pressure was 450 millimetres of cerebrospinal fluid, and there was evidence of a complete block with a protein concentration of 600 milligrams per cent.

Radiographs showed an area of destruction of the superior border of the lamina and pedicle of the first thoracic vertebra on the right side (Fig. 1). The transradiant area was clearly demarcated from the surrounding bone. There was an area of diffuse irregular calcification overlying the neural canal. The lamina of the seventh cervical vertebra was abnormally dense. Tomographs showed that the calcification and bone destruction were most marked in the region of the first right thoracic pedicle. The neural canal was narrowed at this point to about half its normal breadth (Fig. 2). A lateral tomograph showed increased density of the right pedicle and lamina of the first thoracic vertebra around the area of erosion and the central calcification. The main area of destruction was at the attachment of the right pedicle to the body of the first thoracic vertebra.

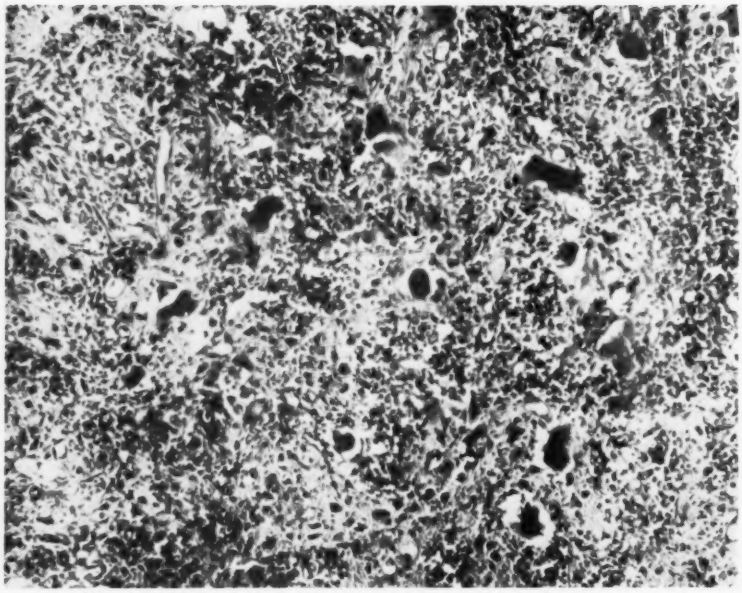

FIG. 4

Case 1—Photomicrograph of tumour showing spindle-celled connective tissue containing numerous osteoclasts. Some small areas of scattered calcification are present, and the tissue contains a considerable number of extravasated red blood corpuscles. (×300.)

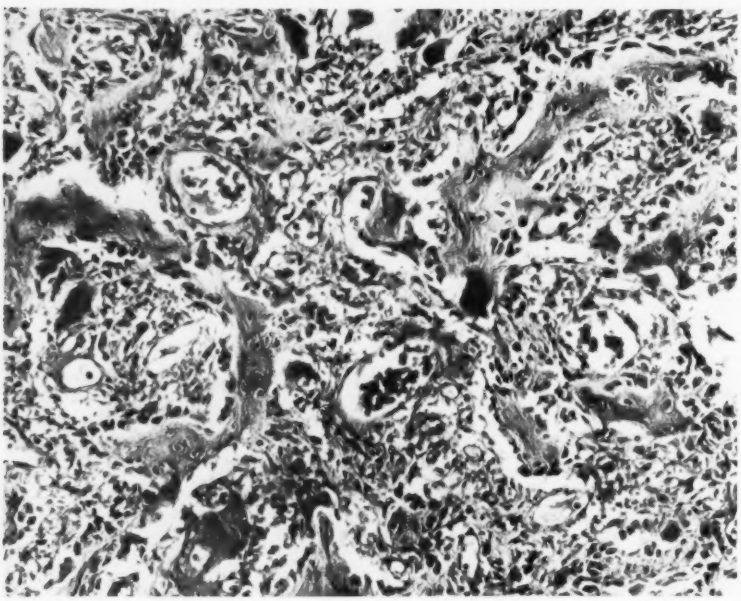

FIG. 5

Case 1—An area from the periphery of the tumour showing an open network of trabeculae of non-lamellar bone with osteoblasts, osteoclasts, and conspicuous blood vessels lying between them. (×290.)

Operation—Laminectomy was performed by Mr H. J. Seddon, who removed a friable purple-red vascular mass which appeared to be arising from the lower surface of the pedicle of the seventh cervical vertebra. This mass had a peculiar gritty consistency and was described as resembling highly vascular callus with areas of cancellous bone. The specimen obtained for histological examination consisted of part of the neural arch to which was attached a mass of tissue about two centimetres in diameter. This friable mass was clearly demarcated from the bone.

Progress—After operation the paraplegia rapidly resolved. Since a provisional diagnosis of osteogenic sarcoma had been made the patient was transferred to the Middlesex Hospital for radiotherapy under the care of Professor B. Windeyer. A tumour dose of 5485r was administered. Radiographs three months after operation showed remarkably dense sclerosis involving the right pedicle and lamina of the seventh cervical vertebra (Fig. 3). The patient has remained free of all symptoms and is able to lead a normal life.

Histological examination—The histological appearance was of a tumour consisting of vascular fibrous tissue, containing numerous osteoclasts and scattered areas of focal calcification and

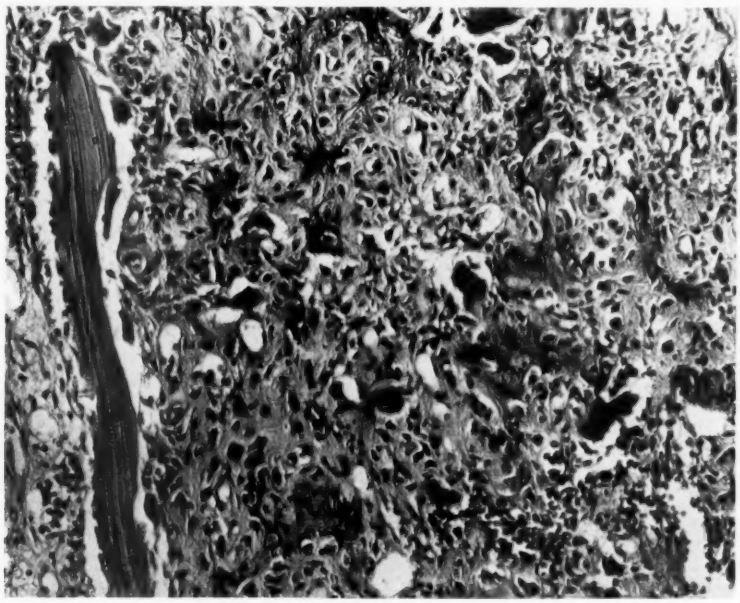

FIG. 6

Case 1—An area of tumour showing uncalcified osteoid. A slender bone trabecula on the left of the field is being eroded by the tumour. (×270.)

ossification (Fig. 4). The periphery contained trabeculae of non-lamellar bone arranged in an irregular network, and surrounded by osteoblasts and osteoclasts (Fig. 5). Some areas of uncalcified osteoid tissue were present (Fig. 6). The lesion, though cellular, did not present the histological features of a malignant bone tumour. In the material examined, there was no histological evidence of a peripheral confining zone of sclerotic bone, the tumour tissue being bordered (Fig. 6) by bone trabeculae of normal dimensions.

Case 2—A girl aged fourteen years was admitted to the Manchester Royal Infirmary under the care of Sir Geoffrey Jefferson, complaining of a constant ache in the lower back, radiating down the backs of both legs, which had become so weak that she was unable to walk. The symptoms had begun a year before, after a fall on to the buttocks. Low back pain developed insidiously and progressed in spite of physiotherapy. Examination revealed severe spasm of the lumbar spine, marked increase of reflexes in the legs and loss of power, particularly in the extensor groups of the legs. A lumbar puncture showed a pressure of 400 millimetres of cerebrospinal fluid and there was a complete block to the flow. A myelogram showed a complete block at the level of the third lumbar vertebra. The radiographs, which are not available for illustration, showed a small indefinite shadow in the region of the right pedicle of the third lumbar vertebra.

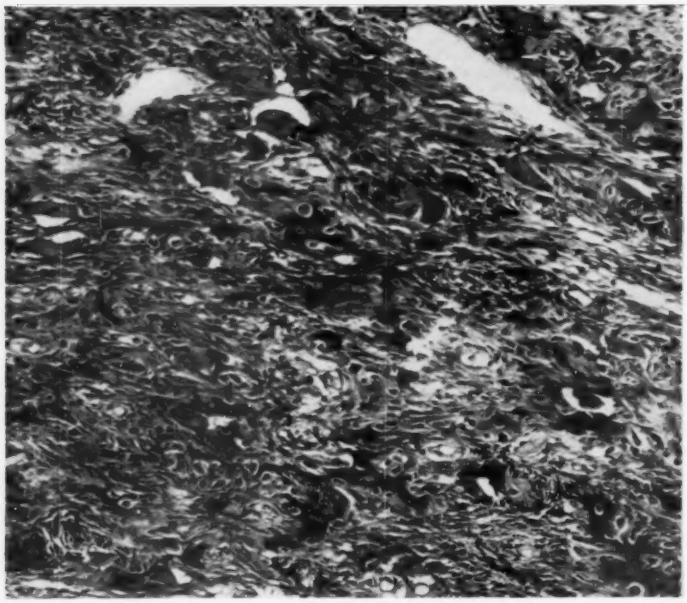

FIG. 7

Case 2—Photomicrograph showing an area of spindle-celled connective tissue containing numerous small spicules of partly calcified non-lamellar bone. (×135.)

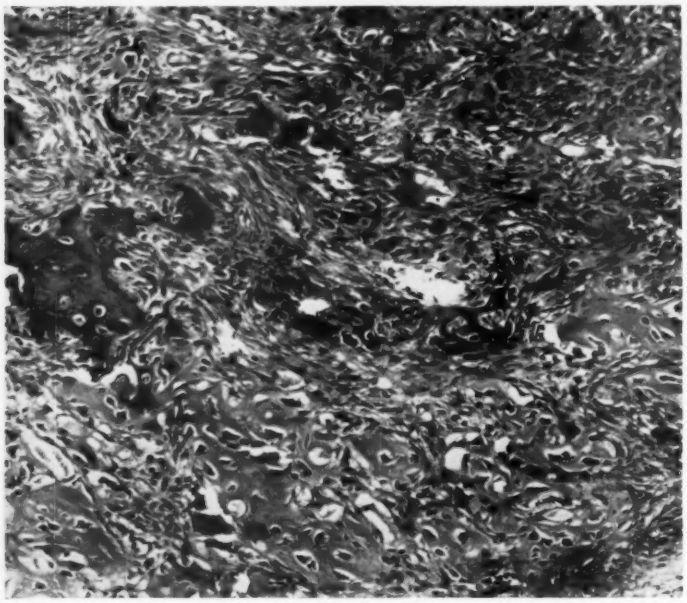

FIG. 8

Case 2—Another field of spindle-celled tumour tissue showing non-lamellar bone and uncalcified osteoid tissue. (×135.)

At operation a vascular tumour about two centimetres in diameter was found to have replaced the lamina and part of the pedicle of the third lumbar vertebra. The tumour was not infiltrating either the dura or the bone. It was removed and was described as being of gritty consistency, purplish in colour, containing sago-like granules. After operation the paraplegia resolved and the patient remained free from symptoms. Since a diagnosis of osteoclastoma had been made on clinical grounds, the patient was treated with 3,600r at the Holt Radium Institute, Manchester. When last seen six years after operation the patient was free of all symptoms.

Histological examination—The specimen measured 2 by 1 centimetre. Over the surface there was an incomplete bony shell covered by a thin layer of fibrous tissue. The lesion consisted of spindle-celled connective tissue containing numerous small spicules of partly calcified non-lamellar bone (Fig. 7), with scattered osteoclasts between the bony spicules. Numerous areas of osteoid tissue

FIG. 9

Case 2—A field showing an irregular mass of calcified non-lamellar bone surrounded by spindle-celled fibrous tissue. (×135.)

were present and appeared as paler areas of uncalcified hyaline collagen containing numerous osteoblasts and occasional osteoclasts (Fig. 8). These areas of osteoid varied considerably in size, some of them being microscopic, others as large as 5 centimetres in diameter. In some areas the calcified bone tissue was arranged, not in isolated spicules, but in a confluent mass (Fig. 9), but the continuous network of bone characteristic of osteoid osteoma was absent.

DISCUSSION

It is evident that the two cases are of benign tumours of bone. In retrospect, the progressive increase in size of the lesions, and their histological appearance, clearly establish that they were neoplastic. The satisfactory clinical results, despite the local piecemeal removal of the lesions with only a relatively small dosage of deep x-ray therapy, suggests further that the tumours were benign. But at the time of surgical exploration diagnosis was difficult, and the following possibilities were considered.

Osteosarcoma—The cellular, osteoblastic, microscopic appearance of the tumours at first sight suggested such a diagnosis, which was actually considered for a time to be the

correct diagnosis in Case 1. In spite of their cellularity, however, the tumours failed to show the numerous mitoses and the atypical and irregular cytological features of a malignant tumour. The relatively circumscribed appearance of the lesions, as seen in the early radiographs in Case 1 (Fig. 1), also might have directed diagnosis away from a malignant tumour.

Osteoclastoma—Despite the rarity of osteoclastomas in patients under twenty years old, the circumscribed osteolytic lesion might suggest such a diagnosis. The presence of some calcification or ossification in the tissue of the lesion is not, however, in keeping with a diagnosis of osteoclastoma, but the scattered osteoclasts might cause confusion. This diagnosis, in fact, was made in Case 2. An impression that osteoclastomas, particularly those with a "spindle-celled structure," are not infrequent in vertebrae in young patients (Geschickter and Copeland 1949) may possibly be explained by the type of lesion here described.

Osteoid osteoma—These two cases show a closer similarity to osteoid osteoma than to osteosarcoma or osteoclastoma. Both they and osteoid osteoma belong to the general group of "benign osteoblastic tumours," and there is considerable histological similarity between the two. Nevertheless a number of features separate them. The lesions described did not cause the severe pain characteristic of osteoid osteoma. They were considerably larger, and showed progressive enlargement with compression of adjacent soft tissues. These features, with the absence of a zone of sclerosis surrounding the lesion which is characteristic of osteoid osteoma, result in a totally different radiographic appearance. Pathologically, the cases consisted of the same tissue components—osteoid tissue and non-lamellar bone, osteoblasts and osteoclasts, and vascular fibrous tissue—but the proportions of each, and their arrangement, were different. In particular, the continuous network of bone and osteoid tissue which makes up the "nidus" of the osteoid osteoma was absent, and there was much more fibrous tissue. The contrast in size between the two types of lesion, and the differences in structure of the surrounding bone, are points of distinction in histological preparations, just as they are in radiographs.

These considerations confirm Lichtenstein's (1952) suggestion that certain "benign osteoblastic tumours" can usefully be separated—both on clinical and pathological grounds—from osteoid osteoma, and can be properly described as "osteogenic fibroma of bone." There is, however, considerable histological similarity between the two conditions, which doubtless indicates a close relationship.

The present two cases compare rather closely with those mentioned by Lichtenstein (1952). One of these involved the spinous process of the third cervical vertebra in a boy of sixteen; the radiographic appearance suggested either a bone cyst or an osteoclastoma, but showed some central ossification. Few details were given of the other cases encountered by Lichtenstein.

Another case which appears to be of the same type is that described by Jaffe and Mayer (1932) as a benign "osteoblastic osteoid tissue-forming tumour" of a metacarpal bone. This lesion, whose relationship to osteoid osteoma has been discussed (Jaffe 1935), occurred in a girl of twelve, and formed an encapsulated mass ten centimetres in greatest diameter. Histologically it consisted of osteoid tissue, bone, and spindle-celled collagenous tissue. There was no recurrence after local excision.

Two cases described by Bergstrand (1930), and mentioned by Lichtenstein as possible examples of osteogenic fibroma of bone, appear to us—from Bergstrand's detailed description of them—to be clear examples of what is now known as osteoid osteoma.

SUMMARY AND CONCLUSIONS

Two cases of benign osteoblastic tumours of the spine, occurring in young patients, and presenting as expanding osteolytic lesions with some central calcification and ossification, are described. It is suggested that they represent a condition allied to, but usefully separated

from, osteoid osteoma of bone. The name osteogenic fibroma of bone, proposed by Lichtenstein for this type of case, is accepted.

Our indebtedness is gratefully acknowledged to Sir Geoffrey Jefferson and to Mr H. J. Seddon for making available clinical details of the patients; to Professor S. L. Baker who directed our attention to Case 2, and who commented on the histological findings in each case; to Dr E. H. Allen who advised on the radiological interpretation in Case 1; and to Dr H. L. Jaffe who examined histological material from the two cases.

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BONE ABSCESS CAUSED BY BACTERIUM COLI

R. MEYER, JERUSALEM, ISRAEL

A girl of eighteen complained of general weakness and pain in the right knee for two weeks, during which there had been mild pyrexia. There was no history of previous illness. She had never been treated with antibiotics for any disease. *On examination* there was visible swelling of the right knee with wasting of the thigh. There was tenderness over the lateral condyle of the femur. Extension of the knee was restricted by 5 degrees, but flexion was normal. Radiographs showed a sharply defined osteolytic lesion with slightly osteosclerotic walls in the lateral condyle of the femur (Fig. 1). Blood sedimentation rate was 55 millimetres in one hour, and blood count showed a leucocytosis of 10,200.

FIG. 1

Radiographs showing the bone cavity before operation.

Operation—The lateral femoral condyle was approached through a straight incision. Deep to the ilio-tibial band a greyish sac was encountered which was firmly adherent to the bone. On opening the sac white pus was obtained. The abscess communicated directly with the bony cavity seen in the radiograph. The cavity was saucerised and the wound closed. Systemic penicillin therapy was ordered.

Progress—After operation the pyrexia continued. Forty-eight hours later the wound was therefore inspected and found infected. The stitches were removed and a considerable amount of pus escaped. The bacteriologist reported that the specimen of pus obtained at the time of operation had grown a pure culture of bacterium coli. One gramme of streptomycin daily was therefore given with the penicillin, but much pus continued to drain from the wound. On the fifth day sensitivity tests revealed that the organism grown from the original

specimen of pus was sensitive only to chloromycetin and was resistant to all other antibiotics used in the test. The use of penicillin and streptomycin was therefore discontinued and a few drops of chloromycetin were instilled into the wound. This treatment was repeated on the seventh post-operative day. On inspection of the wound on the ninth day no more pus was seen and there was granulation tissue. Further bacteriological study showed no organisms apart from non-pathogenic staphylococcus citreus, and the wound healed without further incidents.

Comment—I have not found reference to a bone abscess caused by bacterium coli in the literature. The possibility that this was a sterile abscess (Buchman and Blair 1945) and that the organisms were contaminants was dismissed as the treatment indicated by the sensitivity test had prompt success. The absence of pathogenic staphylococci could not be explained by pre-operative antibiotics (Buchman and Blair 1945) for none was used. In the section on bacterium coli, Jordan-Burrows's *Text-book of Bacteriology* (1949) states: "Local infections such as abscesses, conjunctivitis and the like have been observed, but are not common. Bacterium coli may, on occasion, invade the body tissues and set up a focus of infection."

This case may also serve as a contribution to the question raised by Howard (1951) whether local administration of antibiotics has much effect in osteomyelitis.

SUMMARY

A bone abscess in the distal femoral metaphysis of an eighteen years old girl is described which was found to have been caused by bacterium coli sensitive to chloromycetin only. Surgical treatment combined with local administration of chloromycetin promptly cured the lesion.

I am grateful to Dr K. R. Rabinovitz, Jerusalem District Laboratory, Ministry of Health, for the bacteriological examinations.

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TRAUMATIC THROMBOSIS OF THE ULNAR ARTERY IN THE PALM

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From the Harlow Wood Orthopaedic Hospital

An engineer, twenty-eight years old, was admitted to hospital with pain in his left hand which had been present for ten months. The pain began suddenly after using the palms of his hands to hammer on a chain case in the course of his work. The pain was sharp in character. It had not prevented him from continuing at work but had gradually become worse. About six weeks after the onset he noticed some whiteness in the middle finger of his left hand, accompanied by numbness and tingling. The condition improved slowly, but he found that in cold weather this finger became blue and white.

On admission, his chief symptom was persistent pain, aching in character, in the left palm at the base of the thumb. On examination there was no evidence of a constitutional or cardio-vascular disturbance. The radial pulse was normal. There was no obvious swelling or wasting of the intrinsic muscles of the hand, but there was slight weakness, particularly of the abductor pollicis. There was tenderness over the base of the hypothenar eminence, most marked over the hook of the hamate. A firm cord-like structure about four millimetres in diameter could be felt in the line of the ulnar vessels; it could be rolled over the hook of the hamate, with exacerbation of the aching pain. Exposure of the hand to cold caused cyanosis of the middle finger. In the right hand also there were pain and paraesthesiae affecting the ring and little fingers, and a similar but much smaller cord-like structure was palpable. Radiographs showed no abnormality in the left hand but in the right there was a fracture of the hook of the hamate bone.

Fig. 1

Diagrammatic representation of the operative findings. Section between A and B was excised.

Operation—The left palm was explored. The ulnar nerve was found to be normal but the artery was thickened. It was not pulsating, and felt firm from the level of the pisiform to its division into the superficial palmar arch and the digital vessels to the little finger. Above and below this it looked and felt normal. The thickened segment was resected. The symptoms were relieved by the operation.

Histological examination—The central lumen of the artery was obliterated by organised thrombus, and the vessel wall itself was distorted and expanded by a mass of vascular fibrous tissue which lay partly in the media and partly between the media and adventitia. The lesion appeared to have originated in a haematoma of the vessel wall. It had obliterated and thrombosed the lumen of the vessel, and had itself undergone organisation and almost complete fibrosis.

Comment—It seems remarkable that such a superficial vessel as the ulnar artery, which must be repeatedly subjected to injury, so rarely gives rise to symptoms. As the vessel enters the palm it lies on the flexor retinaculum but is protected to some extent by the

pisiform bone. More distally, it lies under the palmaris brevis muscle, which may also provide some protection. As it passes immediately on the radial side of the hook of the hamate it is superficial and any blow may bruise it against this bony prominence. In the case of this patient's right hand the hamate was fractured; presumably it took the main force of the blow. In the left hand the bone was intact, but the ulnar artery suffered more seriously. The suddenness of the onset of symptoms in the middle finger suggested that they were probably due to an embolus.

So far as I am aware, few other cases of injury to the ulnar artery have been reported. When all its coats are ruptured an aneurysm will result, and this has been described by Regnault and Bourrut-Lacouture (1913), Mauclaire (1897), and Rastouil (1913). When the main injury is to the intima, thrombosis may occur. A lesion like the one described was seen by von Rosen (1934), and Teece (1949) recorded a similar case. Pain and tenderness localised to the base of the hypothenar eminence were described by both authors. Teece also found disturbance of sensation to the fourth and fifth fingers. Complete relief was obtained by excision of the affected arterial segments.

I wish to thank Mr S. A. S. Malkin for permission to publish this case, Dr H. A. Sissons of the Institute of Orthopaedics for his report and Miss G. O. M. Risker for the diagram.

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MYOSITIS OSSIFICANS IN HEMIPLEGIA

J. Irving and H. Le Brun, Ashford, Middlesex, England

From the Ashford Hospital

A seventy-four years old woman was admitted to hospital with left-sided hemiplegia of one day's duration. Movements of the arm and leg were weak, and there was an extensor plantar response on the left side. She was disorientated and had some difficulty in speaking.

The patient's condition remained unchanged until a month after admission, when she complained of pain in the left groin. A swelling was found on the antero-medial aspect of the upper part of the thigh. It was firm and tender and had only limited mobility, but the overlying skin was not adherent or inflamed. No focus of infection could be found in the area drained by the inguinal lymph nodes; there was no evidence of intestinal obstruction and the vertebral column appeared normal. Apart from one rise of temperature to 100 degrees Fahrenheit, there was no pyrexia. The Wassermann reaction and Kahn test were negative, and radiographs of the left hip region showed no abnormality. The swelling was thought to be an abscess, perhaps arising from a strangulated femoral epiplocoele or a deep inguinal lymph node, although the possibility of a soft-tissue sarcoma was borne in mind.

Fig. 1

Extensive myositis ossificans in adductor region of left hip. Appearances were normal five weeks previously.

Treatment and progress — Penicillin (1,000,000 units) and streptomycin (one gramme) were given twice daily for ten days, but the swelling increased in size, eventually measuring $6 \times 3\frac{1}{2}$ inches (15×9 centimetres). It gradually became bony hard and quite fixed. There was no active or passive movement at the hip joint, which was held in flexion, abduction, and lateral rotation. At this stage radiographs showed an irregular ossific mass in the adductor region of the thigh, with no obvious origin from femur or pubis; it resembled closely the myositis ossificans found in certain cases of traumatic paraplegia (Fig. 1). This extensive change had occurred in the short space of five weeks. Death occurred three months after admission without further apparent change in the local condition.

Post-mortem examination—There was atheroma of the cerebral arteries with a large area of softening in the right cerebral hemisphere, extending from the precentral gyrus to the basal ganglia. There was patchy left basal bronchopneumonia, and there was pyelonephritis of the left kidney. No evidence of an abdominal hernia was found. In the upper part of the adductor group of muscles of the left hip was a bony mass measuring $5\frac{1}{2} \times 3\frac{1}{2} \times 2\frac{1}{2}$ inches ($14 \times 9 \times 6$ centimetres). Its cut surface showed cancellous bone arranged for the most part in thick, irregularly disposed trabeculae, between which were islands of grey gelatinous

tissue which appeared to be atrophic muscle (Fig. 2). The new bone was firmly fixed to the periosteum of the pubis, but only loosely adherent to that of the femur. The left hip joint was normal. Histological examination of the lesion confirmed the naked eye appearances. Areas of cancellous bone were separated by loose oedematous connective tissue, in which were scattered large numbers of skeletal muscle fibres. The latter were somewhat atrophic, but in many places cross-striation was quite well marked.

FIG. 2
Section of left hip showing myositis ossificans of adductor muscles.

COMMENT

Localised myositis ossificans appears to have some connection with disease of the central nervous system, but the nature of the relationship is obscure. Heterotopic ossification has long been recognised in cases of traumatic paraplegia, and more recently it has been described in anterior poliomyelitis (Costello and Brown 1951). Brailsford (1948) emphasised the similarity between the radiographic changes seen in myositis ossificans and those occurring in the soft tissues in the neighbourhood of neuropathic joints. This led him to suggest that, in all cases of localised myositis ossificans following contusions, a lesion of the central nervous system might be present, even though it were only a transient vascular disturbance produced by the trauma.

The case reported here is one of hemiplegia due to cerebral haemorrhage, in which myositis ossificans of the adductor muscles of the paralysed hip developed rapidly and caused a swelling in the groin.

We wish to thank Dr A. Barham Carter for permission to record this case, Dr J. A. Brocklebank for the use of the radiograph, and Miss B. E. Nicholson for the drawing.

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DISLOCATION OF THE HIP WITH FRACTURE OF THE FEMORAL HEAD

A Report of Three Cases

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Dislocation of the hip associated with a fracture of the femoral head is a rare injury. Henry and Bayumi (1934), in a review of the literature, mentioned thirteen cases, most of them reported in an article by Christopher (1926) who pointed out that the first case was described in 1869. In nine of these cases reduction was attempted; it was achieved by closed methods in six, and by open operation in the other three. Among the seven survivors, four good results are reported—three after closed reductions and one after operation. Ankylosis occurred in the other three cases. King and Richards (1941) described two cases, both with a fracture of the acetabular lip and both requiring fusion of the hip. Armstrong (1948) described five cases, in three of which manipulative reduction was successful. In the other two reduction could not be obtained by closed methods, and in both cases fusion was required. In one the head was comminuted; in the other the fragment was large. Gordon and Freiberg (1949) wrote of one case in which fracture of the head was not detected until after manipulative reduction.

CASE REPORTS

Case 1—A man aged twenty-five received his injury when a reel of paper weighing six or seven hundredweight rolled on to his back from a small truck that he was pulling up a ramp. He was in great pain, lying with the right leg medially rotated at the hip. A radiograph showed a posterior dislocation of the hip with a large fragment of the femoral head lying within the acetabulum (Fig. 1). Manipulation failed to reduce the dislocation although the head could be made partly to enter the acetabulum, and crepitus could be felt when it impinged upon the fragment lying therein. Four days later open reduction was performed through a postero-lateral incision with detachment of the greater trochanter. The fragment lay in the acetabulum with its articular surface facing outwards, and to it was attached the ligamentum teres. The fragment was removed by screwing into it a Judet head remover, and was found to measure $4 \times 4 \times 2\frac{1}{2}$ centimetres (Fig. 2). The remainder of the femoral head presented a postero-medial defect. The dislocation was reduced easily and remained stable. A single hip spica was applied and retained for eight weeks, after which weight bearing was permitted. A radiograph at that time showed no avascular necrosis of the femoral head. Six months after operation the patient was walking well, and had 90 degrees' hip flexion, almost full abduction and adduction, but marked limitation of medial and lateral rotation. A radiograph again showed no avascular necrosis, and the defect in the head could not be seen (Fig. 3). Eighteen months after operation his range of movement had not changed, and radiographically the head appeared normal. Twenty-eight months after operation the femoral head showed degenerative changes and his range of movement had decreased markedly.

Case 2—A man aged forty-five sustained his injury in exactly the same way as the first patient, and in the same factory. The leg was shortened but not rotated abnormally. Movements of the hip were painful. Radiographs showed the left hip to be dislocated posteriorly, with a large fragment detached from the head lying in the acetabulum (Fig. 4). Open reduction was advised, and manipulation was not attempted.

Operation was performed the next day through a postero-lateral approach, detaching the greater trochanter. The femoral head was found dislocated above and behind the acetabulum. A large fragment was found cleanly detached from the antero-inferior aspect of the head (Fig. 5). To this fragment was attached the ligamentum teres. So large did the

FIG. 1 FIG. 2 FIG. 3

Case 1. Figure 1—Radiograph before reduction. Figure 2—The fragment of head removed. Figure 3—Radiograph six months after operation.

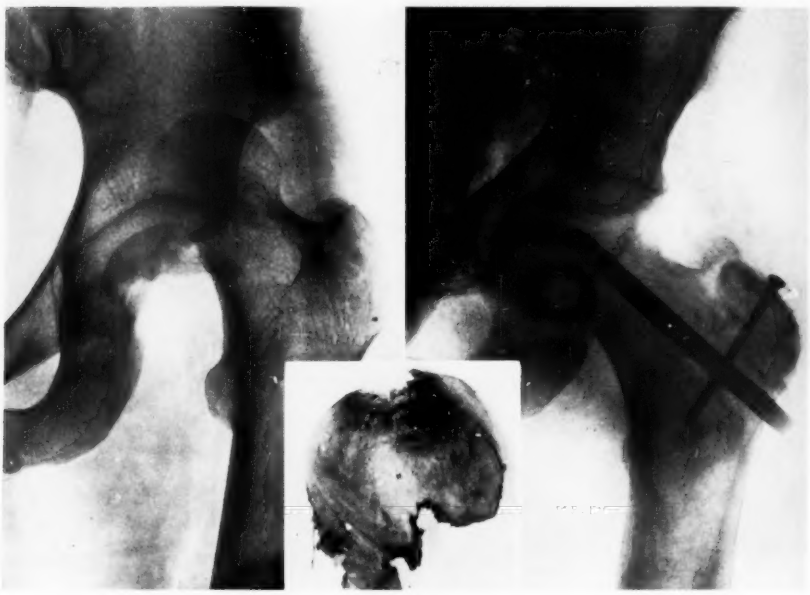

FIG. 4 FIG. 5 FIG. 6

Case 2. Figure 4—Radiograph before operation. Figure 5—Photograph of the detached fragment. Figure 6—Judet prosthesis in position.

defect in the head appear that it was decided to resect all the head and apply a Judet prosthesis. The fragment was removed as in the previous case. A radiograph (Fig. 6) showed the prosthesis to be in good position. Six months after operation the patient walked with an almost imperceptible limp. Flexion at the hip was just over a right angle; abduction and adduction were full; the range of rotation was about 15 degrees short of normal in both directions.

Case 3—A man aged forty-three was struck by a motor car while riding a motor cycle; his left thigh was driven backwards at the hip. The limb lay in medial rotation at the hip with no flexion deformity. Radiographs showed a posterior dislocation with a large fragment of the head retained in the acetabulum (Fig. 7). There was also a severe knee joint injury with cruciate and lateral ligament damage on the same side. Manipulative reduction failed, and

FIG. 7

FIG. 8

Case 3. Figure 7—Before reduction. Figure 8—Seven years after operative reduction.

open reduction was carried out a few days later through an anterior approach. The detached fragment of head was found attached to the ligamentum teres and it was removed. The dislocation was reduced easily and was stable. At first the hip was stiff and painful, but it became painless as ankylosis occurred from ossification in the soft tissues. When last examined seven years after injury the hip was completely stiff but painless (Fig. 8).

We are grateful to Mr Norman Roberts for his permission to publish the details of the third case here reported.

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MYOSITIS OSSIFICANS PROGRESSIVA

Report of a Case in which A.C.T.H. and Cortisone Failed to Prevent Reossification After Excision of Ectopic Bone

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Myositis ossificans progressiva is a rare disease. Strictly, it is misnamed, for the essential pathological change is a metaplasia of connective tissue in and between muscles, leading to the progressive formation of embryonic connective tissue, adult connective tissue, cartilage and bone. Degeneration of muscle fibres and sarcolemmal proliferation follow; the bone formed may contain marrow and is not chemically different from ordinary bone. Sites of this metaplasia may be indicated first by localised, sometimes haemorrhagic, swellings in muscle, appearing spontaneously or after injury. Occasionally familial or twin incidence has been reported and males are affected slightly more often than females. Onset may be in the first year of life, is common in early childhood and rare after adolescence. If tendons are ossified the radiographic appearance may suggest diaphysial aclasis. There is commonly an associated microdactyly affecting the great toes. The main sites of ossification are the muscles of the trunk, the masseters, and the upper arms; the neck and external laryngeal muscles may also be involved. Those of the eye, face, diaphragm, heart, perineum, sphincters and larynx have not been observed to be affected. Excision of ectopic bone has usually been followed by recurrence. Death has commonly followed increasing rigidity leading to pneumonia or chronic sepsis from bed sores. The blood chemistry (including estimation of the serum alkaline phosphatase) has previously been reported to be normal.

This rare disease has recently been reviewed by Fairbank (1950) and Maudsley (1952), and Briggs and Illingworth (1952) have added further cases, the latter recording the results of cortisone treatment. In the case to be described here the patient's metabolic state was investigated fully before and after excision of a mass of bone from the neck (Fig. 1). It was hoped to prevent subsequent reossification by A.C.T.H. and cortisone.

CASE REPORT

The patient was a girl twelve years old at the time of investigation. When she was four she had a cervical abscess after an attack of tonsillitis; the abscess was drained. Soon afterwards localised nodules were noticed in the neck and shoulders. Further swellings developed during the next few months in the neck, back and pectoral and axillary regions. A nodule was excised for pathological examination. The appearances were mostly those of a granulation tissue response to an inflammatory lesion, but the examination did not throw any further light on their cause. Radiographs at that time showed a calcified shadow in the axilla suggestive of myositis ossificans. Other areas of ectopic ossification were subsequently demonstrated.

Limitation of movement in the neck and shoulders increased progressively, and by the time she was eleven there was also a fixed flexion deformity of the left hip which was treated by x-ray therapy with some improvement.

Detailed clinical description—Abnormal areas of new bone formation were present in the posterior cervical region, extending from the occiput to the upper thoracic vertebrae. Neck movement was severely restricted and movements of the neck were accompanied by movements of the right scapula. There was some lateral rotation to the right but only a very small

range of flexion. Nodules of bone were present in both axillae, in the lower thoracic region posteriorly, and in the anterior abdominal wall. In the lower limbs, hip movements were fairly free on the right, but on the left there was a flexion deformity of 50 degrees and the range of flexion was through only a few degrees. A good range of knee and ankle movements was retained. The tendon reflexes were not impaired. In the upper limbs, shoulder abduction was limited to 30 degrees on the right and 50 degrees on the left. Flexion was similarly reduced. The pectoral muscles were diffusely infiltrated with bone.

No abnormality was found in the cardiovascular system. The lungs were normal. Chest expansion was two inches.

Radiographic examination—The pituitary fossa was not enlarged. The neck showed a solid bar of bone extending from the occiput to about the level of the spine of the second and third thoracic vertebrae (Fig. 2); there was a further smaller bar on the right side of the neck behind. There was evidence of congenital fusion of all the cervical vertebrae except the first and seventh. The cervical vertebral bodies and spinous processes were poorly formed. There

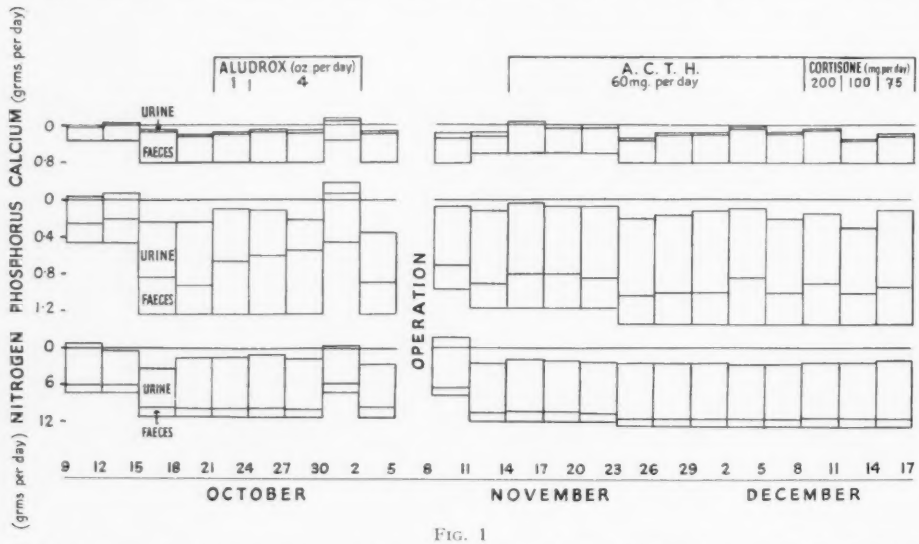

FIG. 1

Metabolic chart. The intakes are measured vertically downwards from the base line marked 0. Positive balance is indicated by the fact that the rectangles showing urinary and faecal output fall below this base line.

were irregular masses of bone in both axillae and scapular regions. The shoulder joints, forearms and hands appeared normal. In the lower limbs the shafts of the long bones were normal, but there were multiple slender exostoses round the knee joints.

In the trunk a solid mass of bone extended downwards from the right lower thoracic region posteriorly, where it was attached to several ribs (Fig. 5). It reached down to the level of the fourth lumbar vertebra. Additional smaller pieces of bone were present on the left side. The lumbar spine showed multiple congenital abnormalities of the articular facets and pedicles. There appeared to be partial fusion of the sacro-iliac joints with a few small plaques of bone in the soft tissues: these were most marked around the neck of the left femur. Both femoral necks were deformed and the acetabula were shallow.

Biochemical investigations (Fig. 1)—Examinations six years before the present investigation had shown serum calcium level of 8·7 milligrams per 100 millilitres, phosphorus 3·8 milligrams per 100 millilitres, alkaline phosphatase 20·9 phenol units per 100 millilitres, and erythrocyte sedimentation rate 7 millimetres in one hour. Investigations at the time of her admission

to the metabolic ward (Fig. 1) gave the following results. *Serum constituents* (per 100 millilitres)—calcium 9·6 milligrams, magnesium 2·4 milligrams, phosphorus 4·8 milligrams, albumin 3·5 grammes, globulin 3·2 grammes, CO_2 combining power 64 vols., alkaline

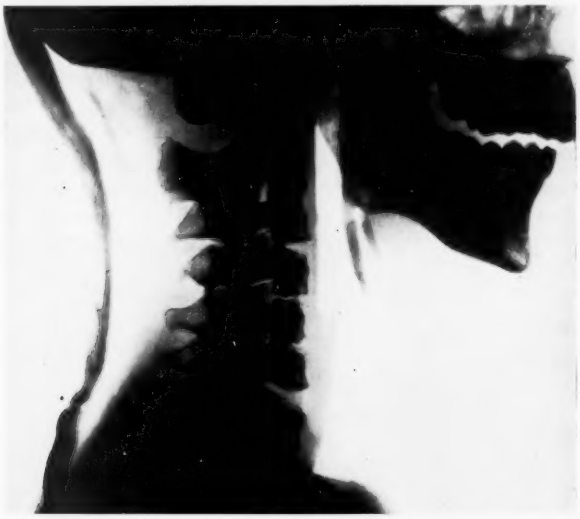

FIG. 2
Neck before operation. Note the distinct posterior bar of bone.

FIG. 3

FIG. 4

Figure 3—Immediately after operation. Figure 4—Seven months after operation.

phosphatase 23·5 phenol units, and vitamin C 1·5 milligrams. *Renal function tests*—Blood urea 43 milligrams per 100 millilitres, urea clearance 100 per cent of normal, phosphorus clearance 13 millilitres per minute (normals range from 8–25 millilitres per minute) increased

to 19 millilitres per minute after parathormone. Urine contained a trace of albumin and a few pus cells but no excess of amino-acids. *Calcifying tendency of serum*—Incubation of a slice of a tibial epiphysis of a rachitic rat in the patient's serum by Robison's (1932) technique showed greatly increased tendency to deposition of bone salt compared with the serum of a normal child of about the same age which contained calcium 10 milligrams and phosphorus 4 milligrams per 100 millilitres.

Treatment and progress—The child was placed on a low calcium diet containing 0·35 grammes of calcium, 0·48 grammes of phosphorus, and 50 grammes of protein, on which she appeared to be in equilibrium. Her serum calcium 9·6 milligrams per 100 millilitres and phosphorus 4·8 milligrams per 100 millilitres, giving Ca × P of 46, suggested that the rather high serum phosphorus value was contributing to the high calcifying tendency. Another factor influencing

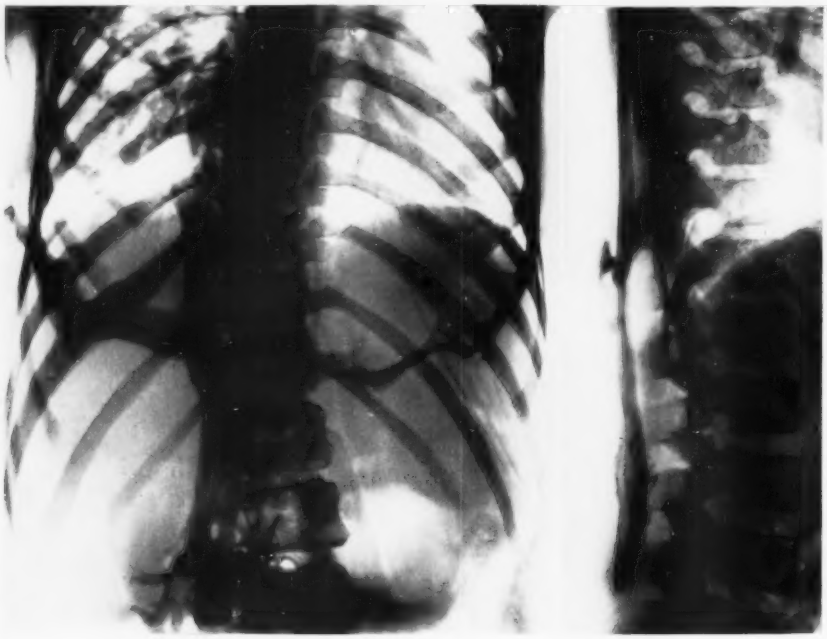

FIG. 5

Antero-posterior and lateral radiographs of the trunk, showing well defined bars of ectopic bone.

calcification by the humoral mechanism is the concentration of magnesium (a high magnesium value inhibiting), but the serum magnesium of 2·4 milligrams per 100 millilitres was in the normal range.

After one week a diet containing 0·89 grammes of calcium, 1·25 grammes of phosphorus, and 70 grammes of protein was given; on this diet she maintained a slight positive balance of each constituent. It was thought that the calcifying tendency of her serum might be decreased if a lower phosphate level could be produced. Attempts to do this were made by administering alumina to reduce phosphate absorption from the gut. Aludrox (5·6 per cent aluminium hydroxide) was given, the dose being increased from 1 ounce per day initially to 2 ounces after three days and thereafter four ounces daily for one week. At the same time the phosphorus intake was reduced to 0·4 gramme daily. On this regimen the blood phosphorus was not appreciably changed, but the urine phosphorus was reduced from 600 milligrams per diem to 60 milligrams.

Operation—Four weeks after her admission to hospital the middle two-fourths of the bony bar running down the back of the neck was excised by Mr J. A. Cholmeley in an attempt to restore lateral flexion of the neck (Fig. 3).

Pathological examination of excised bone (Dr H. A. Sissons)—The specimen consisted of normal dense lamellar bone, and showed a central " marrow cavity." It was too dense to be suitable for histochemical examination. The surface of the surrounding fibrous tissue showed a layer of osteoblasts and recently formed bone trabeculae, and in the immediate neighbourhood of these a considerable amount of alkaline phosphatase could be demonstrated. The remainder of the fibrous tissue and muscle was entirely devoid of bone, and no alkaline phosphatase could be demonstrated in it. No abnormal metachromasia was demonstrable in the fibrous tissue. Chemical analysis showed water 20 per cent, ash 52 per cent, calcium 18·7 per cent, phosphate 26 per cent, protein 21 per cent, carbonate 3·05 per cent. These values are within the limits accepted for normal bone.

Post-operative treatment—From one week after operation 15 milligrams of ACTH were given four times a day for twenty-five days. The diet contained 600 milligrams of calcium and 1,100 milligrams of phosphorus, on which a slight positive calcium balance was maintained.

Thereafter cortisone was given by mouth in the following dosage: 50 milligrams six-hourly for three days; 25 milligrams six-hourly for three days; and 25 milligrams eight-hourly for seven days. No demonstrable change in the metabolism of calcium, phosphorus or nitrogen was produced by ACTH or cortisone (Fig. 1).

Further progress—The patient was discharged from hospital after completion of the treatment described, but she continued to take cortisone in doses of 12·5 milligrams four times a day (50 milligrams a day) for a further three months.

Up till that time (four months after operation) there was no clinical evidence of reossification in the area from which the bone had been excised. There was a range of 45 degrees rotation of the head to the right and 30 degrees to the left; a small range of flexion and extension was possible. A month later the range of movement was unchanged. But after a further two months (seven months after operation) the patient reported that she had noticed a swelling deep to the scar on the back of the neck for a previous three weeks. Radiographs showed a zone of irregular ossification at the site of operation (Fig. 4). Critical re-examination of the earlier post-operative radiographs showed that progressive ossification had in fact begun to occur nine weeks after the operation.

Comment—There are no exact data on the rapidity of reossification at the sites of injury or operative intervention in myositis ossificans progressiva. Nevertheless it seems certain that in this case cortisone in the dosage given had no effect in retarding the process of re-ossification, which was manifest only nine weeks after excision of a bar of bone.

SUMMARY

1. A metabolic study in a case of myositis ossificans progressiva is reported.
2. The serum showed an increased power of calcification of rachitic rat cartilage.
3. Estimations of alkaline phosphatase showed slightly raised values.
4. Surgical removal of a bony bar was followed by prolonged administration of ACTH and cortisone, but no effect on the calcium-phosphorus balance or on the re-ossification within the area of operation was observed.

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RANGE OF MOVEMENT OF THE GREAT TOE IN MEN

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It is accepted that there is considerable variation in the range of movement at any particular joint in different individuals but quite often precise quantitative data are not available. Some joints with relatively simple hinge movements can be investigated fairly easily by lateral radiography. The metatarso-phalangeal and interphalangeal joints of the big toe lend themselves to this type of investigation. Since this toe is particularly susceptible to pathological changes such as hallux valgus and hallux rigidus, a knowledge of the normal variation in the range of movements may be of some assistance in finding a cause for these conditions.

MATERIAL AND METHOD

Fifty men were studied. They were divided into three groups according to age: seventeen were less than thirty years of age, seventeen were between thirty and forty-four years, and sixteen were aged forty-five or over. Lateral radiographs of the big toe of each foot were taken, centred on the metatarso-phalangeal joint: 1) in the normal plantigrade (" neutral ") position; 2) in full active flexion; 3) in full active dorsiflexion; and 4) in full passive dorsiflexion.

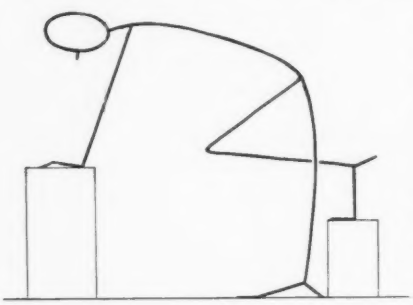

FIG. 1

Position of subject for obtaining radiographs of full passive dorsiflexion at the metatarso-phalangeal and interphalangeal joints.

During passive dorsiflexion the subjects were asked to keep their big toes on the stand used for this investigation and to bend the foot at the big toe as far forwards as possible by leaning forwards on a stool (Fig. 1).

Note was made of the occupation, height, weight, size of shoes, and whether the subject was right-handed or left-handed. Both a personal and family history were taken with special reference to the feet, attention being directed to the mode of walking and running, the way in which shoes were worn, difficulty with shoes, athletic prowess, and previous injuries. The feet were examined for the presence of hallux valgus.

Lateral radiographs of the metacarpo-phalangeal joints of the thumbs were taken because Harris and Joseph (1949) reported limited flexion associated with flattening of these joint surfaces. A similar condition of the metatarso-phalangeal joint of the big toe may exist and this may be associated with flattening of the corresponding joint of the thumb.

The following axes were used for measuring the angles at the metatarso-phalangeal and interphalangeal joints in the radiographs (Fig. 2). The dorsal aspect of the first metatarsal shaft forms a straight line, and a line along this edge of the bone as seen in a radiograph corresponds closely to the long axis of the bone itself (A–A). The long axis of the proximal phalanx was determined by a line which bisected at right angles its narrowest part (B–B). The distal phalanx is curved dorsally but has a relatively flat part on its dorsal aspect. A line drawn along this flat part was used as the long axis of this phalanx (C–C). This axis increases the real angles of dorsiflexion at the interphalangeal joint (or decreases the real angle of plantar flexion).

The angles *a* and *b* in Figure 2 were measured in all the radiographs of the " neutral " position. Most of these angles indicate that in normal standing the proximal phalanx is slightly dorsiflexed on the metatarsal and that the distal phalanx is partly dorsiflexed on the proximal phalanx. In many cases, however, the distal phalanx is plantar-flexed on the proximal, and in these the angle was expressed as a negative angle (Fig. 3, angle *d*).

In plantar flexion the angles *e* and *f* in Figure 4 were measured. These angles were expressed as negative angles if after full movement the axes still showed a position of dorsiflexion. In dorsiflexion, whether active or passive, the angles *g* and *h* in Figure 5 were measured. If after full movement the axes showed a position of plantar flexion, the angles were expressed as negative. The actual range of movement at the two joints was expressed as the movement

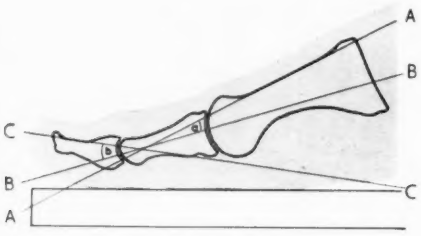

FIG. 2

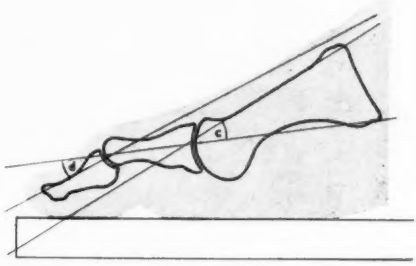

FIG. 3

Figure 2—Axes used for measuring angles at metatarso-phalangeal and interphalangeal joints in the " neutral " position. $a = 11$ degrees; $b = 24$ degrees. Figure 3—Plantar-flexed interphalangeal joint in " neutral " position. $c = 25$ degrees; $d = -21$ degrees.

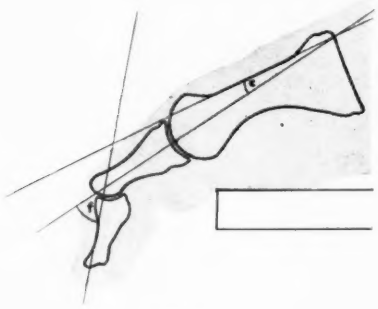

FIG. 4

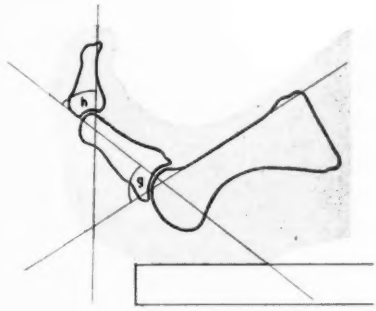

FIG. 5

Figure 4—Angles measured in active plantar flexion. $e = 13$ degrees; $f = 47$ degrees.
Figure 5—Angles measured in active and passive dorsiflexion. $g = 70$ degrees; $h = 54$ degrees.

from the " neutral " position. For this reason the fact that the lines chosen to represent the axes of the bones do not correspond to the actual axes can be ignored.

A possible source of error was that the axes chosen for each individual's radiographs were not always the same. By superimposing the four radiographs of each big toe it was possible to check that the axes chosen for the three bones in each film corresponded.

Another possible source of error was the lateral deviation of great toes that showed some degree of hallux valgus. P. Venning, radiographer at the Department of Anatomy, University College, London, kindly worked out the effect of the valgus angle. Thus, 30 degrees of valgus deformity would reduce an angle of 30 degrees of plantar flexion to one of about $26\frac{1}{2}$ degrees of plantar flexion. Although the valgus angle in the present investigation of 100 feet was not measured, there were no cases of marked valgus deformity. Hardy and Clapham (1951)

in a series of 252 " normal " feet found that the valgus angle between the metatarsal and proximal phalanx had a mean of 15·7 degrees and a standard deviation of the series of 6 degrees. It can be assumed that the figures given by these authors would apply to the feet examined in this paper. In addition, a marked valgus deformity would produce a gross distortion of the phalanges in a lateral radiograph and this was never seen. The effect of a valgus deformity was therefore ignored.

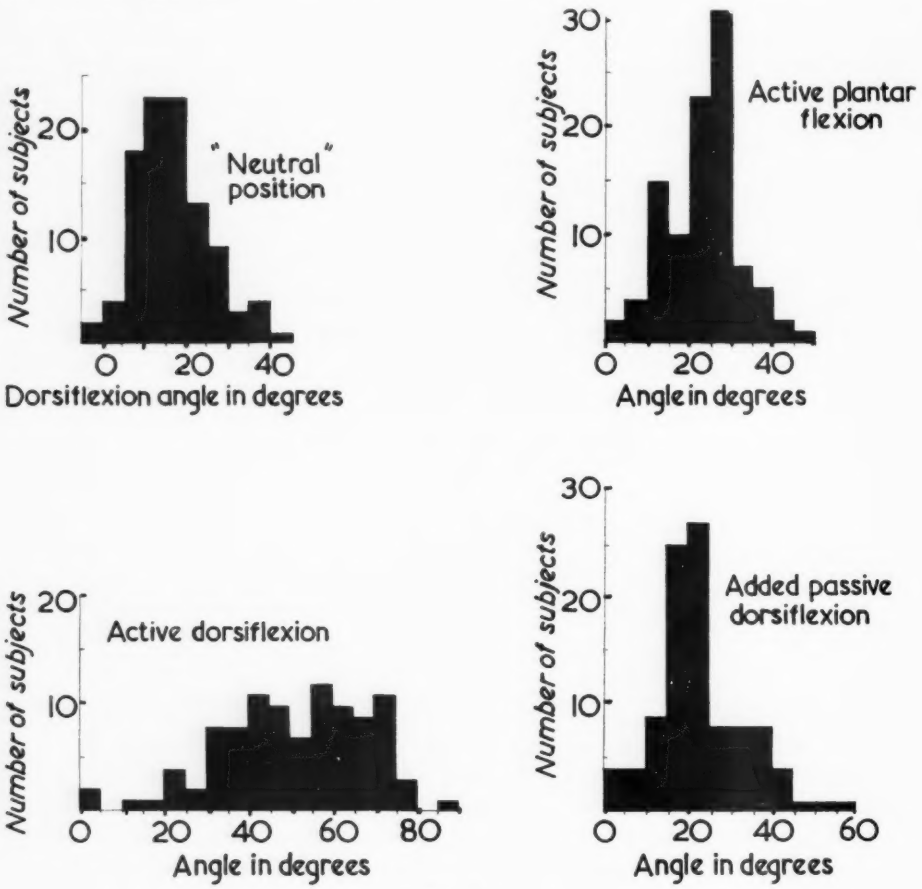

FIG. 6

Histograms of the angles at the metatarso-phalangeal joints in the " neutral " position and of the range of active plantar flexion and active and additional passive dorsiflexion.

The observations on the right and left feet of each age group for each of the positions (" neutral," active plantar flexion, active dorsiflexion and additional passive dorsiflexion) were analysed separately. Tests of significance between right and left sides and between the three age groups were carried out; and the relationship between active and additional passive dorsiflexion at each joint, and between maximal passive dorsiflexion at both joints, was investigated.

OBSERVATIONS

The metatarso-phalangeal joint—Table I gives the means of the angles at the metatarso-phalangeal joints of the right and left big toes in the " neutral " position (expressed as an

angle of dorsiflexion) and the means of the range of movement of active plantar flexion and dorsiflexion (both active and additional passive) in the three age groups.

With only one exception, there is no significant difference between the means of the right and left sides and between the means of the different age groups in any of the four

TABLE I

MEANS OF THE ANGLES (IN DEGREES) OF THE METATARSO-PHALANGEAL JOINTS OF THE BIG TOE IN THE NEUTRAL POSITION, AND OF THE RANGE OF MOVEMENT OF ACTIVE PLANTAR FLEXION AND DORSIFLEXION (BOTH ACTIVE AND ADDITIONAL PASSIVE)

Age	Side	Neutral position (dorsiflexion) (*degrees*)	Active plantar flexion (*degrees*)	Dorsiflexion		Number of observations
				Active (*degrees*)	Additional passive (*degrees*)	
Up to 30	R	15·8 (2·4)	25·6 (1·8)	54·2 (3·8)	23·7 (2·8)	17
	L	17·4 (2·2)	24·5 (1·9)	56·0 (3·4)	21·1 (2·2)	17
30–45	R	15·7 (1·8)	23·9 (2·2)	51·6 (4·3)	24·7 (1·8)	17
	L	13·1 (2·1)	23·3 (1·9)	51·6 (3·9)	22·9 (2·4)	17
Over 45	R	16·2 (2·0)	17·6 (2·3)	46·3 (4·0)	24·6 (4·0)	16
	L	18·9 (2·2)	21·1 (2·4)	44·1 (5·7)	18·6 (2·5)	16

The figures in brackets are the standard errors of the means

positions considered. The exception is the mean angle of plantar flexion of the right side of the group over forty-five. The mean angle is significantly different from the similar mean angles of the younger age groups ($p<0{\cdot}01$).

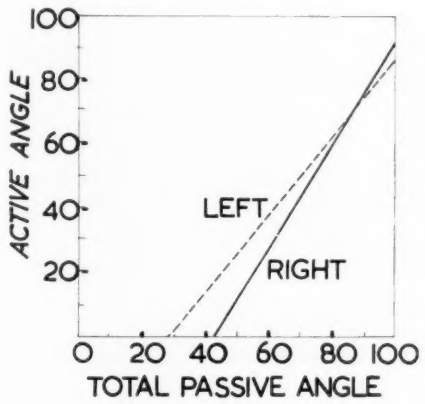

FIG. 7

Calculated relationship between total passive dorsiflexion and active dorsiflexion at the metatarso-phalangeal joints.

Figure 6 is a series of histograms which show the distribution of the angles in each of the four positions studied. These histograms emphasise the very wide variation between individuals.

When the relationship between the angle of active dorsiflexion and the angle of additional passive dorsiflexion is considered, it is found that the greater the angle of active dorsiflexion, the smaller is the angle of additional passive dorsiflexion. An examination of individual

results does not show this relationship in every case, but taking all the data for the right feet and left feet it was found that for a given reduction in the angle of active dorsiflexion the angle of additional passive dorsiflexion increased. This is more marked in the left than in the right feet. This relationship between the two angles is shown in Figure 7, where the total angle of dorsiflexion (active plus additional passive) has been plotted against the angle of active dorsiflexion. These lines may be calculated from the equation $y=a-bx$ (y=the angle of additional passive dorsiflexion and x=the angle of active dorsiflexion). For the right foot $a=43{\cdot}00$ and its standard error is $\pm 6{\cdot}25$; and $b=0{\cdot}37$ and its standard error is $\pm 0{\cdot}09$. For

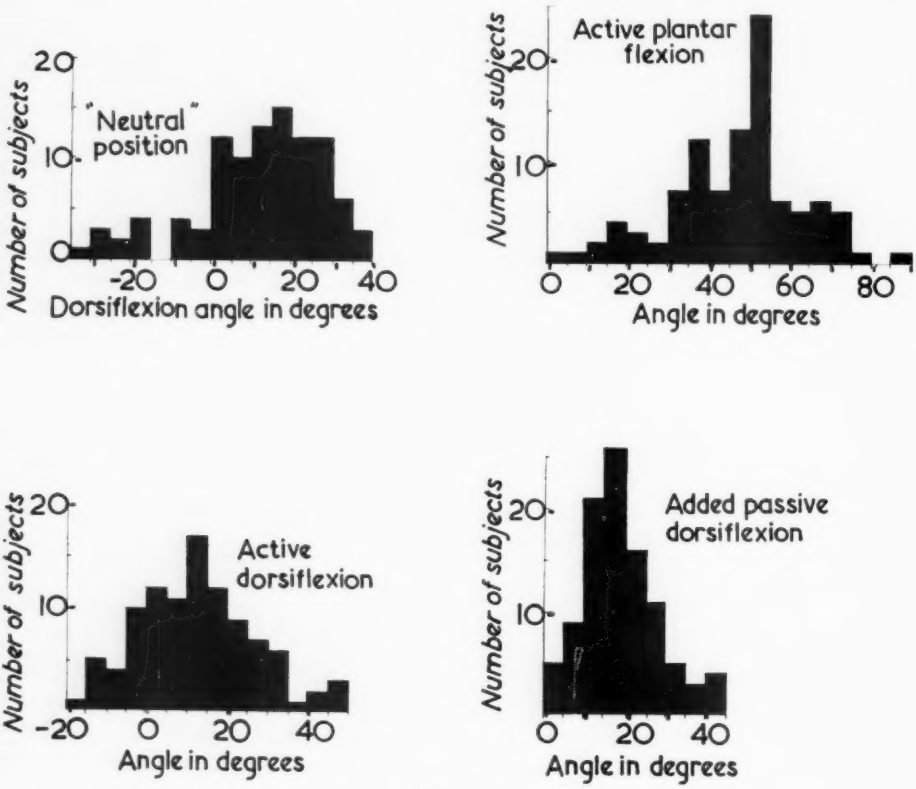

FIG. 8

Histograms of the angles at the interphalangeal joints in the " neutral " position and of the range of active plantar flexion and active and additional passive dorsiflexion.

the left foot $a=28{\cdot}30$ and its standard error is $\pm 5{\cdot}47$; and $b=0{\cdot}15$ and its standard error is $\pm 0{\cdot}07$. The values of a and b are obtained by the method of least squares.

The interphalangeal joint—Table II gives the means of the angles at the interphalangeal joints of the right and left big toes in the " neutral " position (expressed as an angle of dorsiflexion) and the means of the range of movement of active plantar flexion and dorsiflexion (both active and additional passive) in the three age groups.

If the means of the right and left sides and the means of the different age groups are compared, the only significant differences in all the four positions considered are those between the means of the right feet of the youngest age group and the means of the right feet of the other two age groups ($p=0{\cdot}01$), and between the mean of the left feet of the oldest group and the left feet of the younger two groups ($p=0{\cdot}01$) after active plantar flexion.

Figure 8 is a series of histograms showing the distribution of the angles in each of the four positions studied. As in the metatarso-phalangeal joint, these histograms indicate the wide variation between individuals.

When the relationship between the angles of active dorsiflexion and the angles of

TABLE II

MEANS OF THE ANGLES (IN DEGREES) AT THE INTERPHALANGEAL JOINTS OF THE BIG TOE IN THE NEUTRAL POSITION, AND OF THE RANGE OF MOVEMENT OF ACTIVE PLANTAR FLEXION AND DORSIFLEXION (BOTH ACTIVE AND ADDITIONAL PASSIVE)

Age	Side	Neutral position (dorsifexion) (*degrees*)	Active plantar flexion (*degrees*)	Dorsiflexion		Number of observations
				Active (*degrees*)	Additional passive (*degrees*)	
Up to 30	R	10·8 (3·9)	55·4 (2·8)	16·0 (3·2)	16·0 (2·1)	17
	L	9·5 (2·8)	51·1 (3·6)	15·7 (3·5)	18·6 (2·2)	17
30–45	R	9·1 (3·1)	41·7 (3·7)	12·8 (3·3)	18·4 (1·6)	17
	L	14·7 (3·5)	48·5 (3·5)	10·2 (2·4)	18·1 (1·6)	17
Over 45	R	13·4 (4·9)	42·6 (4·3)	7·3 (3·6)	22·4 (3·2)	16
	L	12·2 (4·9)	37·4 (4·2)	9·8 (4·5)	20·6 (2·6)	16

The figures in brackets are the standard errors of the means.

additional passive dorsiflexion at the interphalangeal joint is considered, it is found that, as in the case of the metatarso-phalangeal joint, for a given reduction in the angle of active dorsiflexion the angle of additional passive dorsiflexion is increased. This relationship between the two

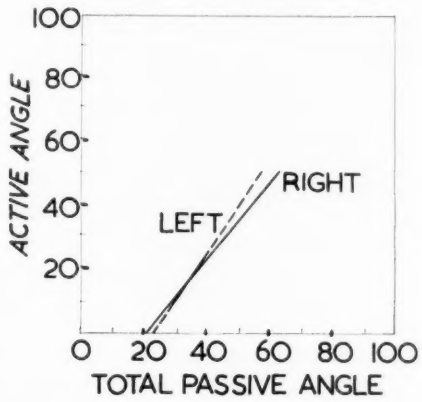

FIG. 9

Calculated relationship between total passive dorsiflexion and active dorsiflexion at the interphalangeal joints.

angles is shown in Figure 9, where the total angle of dorsiflexion (active plus additional passive) has been plotted against the angle of active dorsiflexion. These lines are calculated by the same method as used for the metatarso-phalangeal joints. For the right foot $y=20{\cdot}91\ (\pm 3{\cdot}88)-0{\cdot}17\ (\pm 0{\cdot}10)x$, and for the left foot $y=22{\cdot}30\ (\pm 1{\cdot}45)-0{\cdot}27\ (\pm 1{\cdot}45x)$ (y = the angle of additional passive dorsiflexion and x = the angle of active dorsiflexion).

If the total passive angle of dorsiflexion at the metatarso-phalangeal joint is compared

with the total passive angle of dorsiflexion at the interphalangeal joint, no significant correlation is found.

The shape of the heads of the first metatarsal and first metacarpal—Although ten of the 100 metacarpals radiographed can be described as flat—a similar percentage to that found in previous investigations by Harris and Joseph (1949) and by Joseph (1951)—none of the 100 metatarsal heads as seen in a lateral radiograph can be described as flat, although some were obviously less rounded than others. Three metatarsal heads showed what is usually described as " lipping " of the edge of the metatarsal head on its dorsal aspect, but this could not be related to the range of movement at the metatarso-phalangeal joint.

DISCUSSION

Although a full personal and family history was taken it was impossible to find a relationship between the history and the range of movement at the joints studied. What is very striking is that some conditions that are regarded as a deviation from the normal are associated with a well functioning foot and a normal range of movement. Examples of these are the presence of hallux valgus, and a plantar-flexed interphalangeal joint. It is probable that a certain amount of deviation of the big toe in a lateral direction is normal. This confirms the observations of Hardy and Clapham (1952) in children. With regard to the plantar flexion of the terminal phalanx, of the 100 big toes investigated seventeen showed this in the neutral position. In nine it was unilateral (five right and four left) and in four it was bilateral. Of these seventeen toes, ten showed an associated large angle of dorsiflexion at the metatarso-phalangeal joint—that is, an angle of more than 25 degrees.

It can be seen from Tables I and II that the range of plantar flexion at the metatarso-phalangeal joint is small but dorsiflexion is much freer, whereas the opposite is the case at the interphalangeal joint. Actually in most cases plantar flexion at the metatarso-phalangeal joint brings the proximal phalanx into approximately a straight line with the metatarsal, and similarly dorsiflexion of the terminal phalanx does not bring it much beyond a straight line with the proximal phalanx. It is clear why dorsiflexion of the metatarso-phalangeal joint is important in walking, but it is more difficult to find an explanation for the marked plantar flexion possible at the interphalangeal joint. Gripping with the terminal phalanx may be one of its main functions, and the marked plantar flexion that can occur at the interphalangeal joint may be associated with this.

The adequate range of dorsiflexion required for normal walking is not known, but it is obvious from the figures in the Tables that the total passive dorsiflexion at the metatarso-phalangeal joint in most feet is adequate for this purpose. If the total passive dorsiflexion at the interphalangeal joint is added to that of the other joint, the " take-off " position in walking will rarely, if ever, be affected by the lack of dorsiflexion of the big toe, as is shown by the mean total passive angle of dorsiflexion at the metatarso-phalangeal joint, which is about 75 degrees and that of the interphalangeal joint, which is about 31 degrees.

The significant differences in plantar flexion which are associated with age, and to which reference has been made in the results, are not of much functional significance. It is difficult to see what effect limited plantar flexion at the joints studied can have in the normally functioning foot. On the other hand the decrease in active movement associated with the increasing age of the subjects is not unusual. Perhaps the absence of significant differences between the three age groups in many of the movements is of greater interest.

A study of the histograms brings out the wide variations that exist between different subjects. Attention has already been drawn to the variation in the angles found in the neutral position. The range of plantar flexion at the metatarso-phalangeal joint is from 3 degrees to 43 degrees, and at the interphalangeal joint from 0 degrees to 86 degrees. Similarly the range of total passive dorsiflexion at the former joint varies from 40 degrees to 100 degrees and at the latter from 6 degrees to 73 degrees.

It may be pointed out that the mean total movement at the interphalangeal joint in the group below thirty years of age is approximately 85 degrees in both the right and left feet. Bingold and Collins (1950) stated that they found a " hypermobile " interphalangeal joint with adolescent hallux rigidus, 60 to 70 degrees of passive dorsiflexion being often present. If they had accurately measured the movements of this joint it would have been interesting to see whether their group of cases showed a significant increase in passive dorsiflexion as compared with the observations made in the present study. Clinically there is an important conclusion to be drawn from this investigation. The negative correlation between active and additional passive dorsiflexion at both joints of the big toe makes it necessary to check not only active dorsiflexion but passive dorsiflexion when examining the big toe.

With regard to the shape of the metatarsal head, Hardy and Clapham (1951) found a flattening associated with limited movement. On further inquiry it was found that the flattening referred to by them was from side to side and not from dorsal to plantar aspect. As has already been noted, no case of flattening was seen in this investigation—that is, the metatarsal head did not appear flattened in a lateral radiograph. It is rather puzzling why side-to-side flattening should be associated with limited plantar and dorsiflexion, unless there is some element of abduction or adduction in the movements.

SUMMARY

1. The range of variation in the movements at the metatarso-phalangeal and interphalangeal joints of the big toe in fifty males has been investigated by means of lateral radiographs.
2. In the " neutral " position the proximal phalanx is dorsiflexed on the metatarsal and the distal phalanx dorsiflexed on the proximal. Sometimes the distal phalanx is plantar flexed on the proximal but this is not associated with any obvious abnormality of function.
3. There is a wide variation between individuals in the amount of movement found at these joints.
4. At the metatarso-phalangeal joint dorsiflexion is much more free than plantar flexion. The opposite is the case at the interphalangeal joint.
5. There is no significant difference between the right and left sides. Only in plantar flexion at both joints are there significant reductions in the range of movement in older age groups. These reductions are not functionally important.
6. There is an inverse relationship between active and passive dorsiflexion: the greater the range of active dorsiflexion, the less is the range of additional passive dorsiflexion.
7. In lateral radiographs the head of the metatarsal is always rounded.

I wish to thank Dr J. N. Hunt for help with the statistics and the Department of Medical Illustration, Guy's Hospital, for the Figures.

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TISSUE CHANGES IN HUMAN FEMURS CONTAINING PLASTIC APPLIANCES

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This report is based on the post-mortem examination of eight femurs carrying femoral head prostheses of the type described by Judet and Judet (1950). The patients, all of whom were elderly, had died from two to thirteen weeks after operation. Brief data relating to them are contained in Table I.

TABLE I

DATA RELATING TO PATIENTS WITH PLASTIC FEMORAL HEAD PROSTHESES EXAMINED AT AUTOPSY

Case	Sex	Age	Reason for arthroplasty	Interval between operation and death
1	F	88	Fracture	14 days
2	F	81	Fracture	18 days
3	F	72	Fracture	24 days
4	F	83	Fracture	8 weeks
5	M	70	Fracture	10 weeks
6	M	73	Osteoarthritis	11 weeks
7	F	69	Fracture	12 weeks
8	F	84	Fracture	13 weeks

METHODS

The upper half of the femur was removed at necropsy. The acetabulum was inspected and sometimes also removed. After tapping out the prosthesis the cylindrical stem of which was buried from 6 to 8 centimetres in the bone, the track, or tunnel, was laid open by a vertical saw cut through the whole or part of its length (Fig. 1). Blocks of tissue were cut with a fine saw, either parallel with or across the axis of the track. After decalcification in citric-formic acid, they were embedded in paraffin wax. Sections were cut at 6–20 microns and stained with haematoxylin and eosin and other stains when necessary. The thicker sections gave good topographical pictures. A polariser and eyepiece analyser were helpful in studying the character and arrangement of collagen fibrils in new and old bone and in the repair tissues.

NAKED-EYE EXAMINATION

The stem of the prosthesis was always found to fit tightly in its intra-osseous socket, even in the presence of mild sepsis (Case 1) or of metastatic carcinoma (Case 5). The later models of prosthesis, with grooved stem, could not be rotated in the bone without the use of considerable force to break down the corresponding ridges of organising fibrin which sprang from the track wall. Each peg-track, from two to thirteen weeks, showed a coherent soft lining membrane, ridged or smooth according to the contour of the inserted stem (Fig. 2). When only fourteen to twenty-four days had elapsed since operation, the lining was dark

FIG. 1

Case 7—Upper end of femur showing the fibrous membrane which lines the tunnel and is closely applied to the stem of the prosthesis. Twelve weeks after operation.

FIG. 2

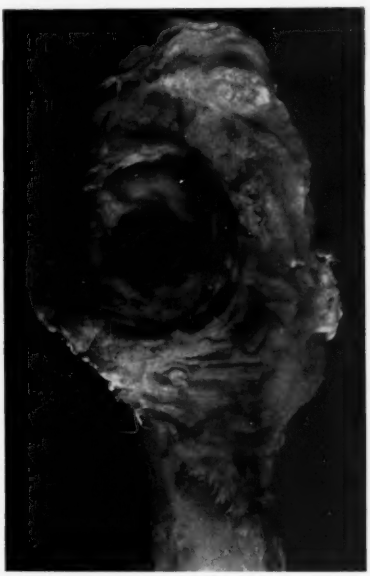

FIG. 3

Figure 2. Case 8—Tunnel in femur thirteen weeks after operation. The lining membrane is of well organised fibrous tissue and clearly shows the ridges corresponding to the grooves on the stem of the Judet appliance. The dark zone in the wall outside the fibrous membrane is vascular osteogenic repair tissue.

Figure 3. Case 6—The entrance to the peg-socket in a femur eleven weeks after a Judet arthroplasty. The smoothly rounded lip is first formed by blood clot moulded to the concave under-surface of the head of the prosthesis. The clot becomes organised. In this picture it shows pale confluent areas of fibrosis.

red, moist and spongy, consisting mainly of fibrin clot with enmeshed red cells. In the specimens obtained eight to thirteen weeks after operation the lining was organised, membranous and pale, and tended to strip from the circumferential bone.

The lip of the tunnel was generally formed of red spongy moist tissue, the red colour being due at first to the blood clot filling the recess under the mushroom head of the appliance and later to the highly vascular granulation tissue invading the clot from the opened marrow spaces of the amputated femoral neck. Pale areas of fibrosis on the surface of the lip were seen in the later specimens (Fig. 3).

FIG. 4

Case 6—Acetabulum with a smooth thick blood-clot lining eleven weeks after Judet arthroplasty. This acetabulum was not reamed, but the clot adheres to osteoarthritic defects in the cartilage and it shows some organisation.

The hip joint space between the plastic head and the natural acetabulum was always filled with a saucer-shaped blood clot which, when the joint was disarticulated, adhered rather to the acetabulum than to the smooth plastic head (Fig. 4). When cartilage has been removed from any part of the acetabulum, either by reaming or by disease, granulation tissue tends to grow out and invade the clot. I have observed this process to lead to the resurfacing of the acetabulum with fibrous tissue in long-standing cup arthroplasties, but no Judet arthroplasty of sufficient duration to show this change was included in the present series; it may be that an early restoration of movement might grind up the fibrin clot which would be eventually absorbed.

HISTOLOGY

The boring tool used to excavate the socket for the Judet prosthesis cuts a cleanly outlined tunnel and causes little damage to the remaining bone (Fig. 5). Many trabeculae are, of course, fractured by the tool, but the cancellous bone shows little comminution, and only a few microscopic sequestra can be seen in sections of the tunnel wall. Moreover, haemorrhage into the marrow spaces is limited to a zone only two to four millimetres in depth around the cavity. This is the zone in which the repair tissues develop and through which they advance to reach and to organise the blood-clot sheath around the plastic peg. The process of repair within the bone is basically the same as that seen after any fracture and, since the repair tissue forms new bone in discrete islands and in apposition to old trabeculae, it would be just to call it endosteal callus. Differentiation into cartilage has, however, never been observed, a fact possibly accounted for by the complete immobility of the tissues, and the final achievement of the repair activities is not the union of the opposing bone surfaces but the sequestration of the implanted foreign body and the sealing off of the exposed spongiosa.

Observations made on many sections from each of the eight cases permit the following timetable of events to be outlined. At fourteen days, fibroblasts and new capillaries are advancing through the blood-filled marrow spaces. There is evidence of osteogenesis in the new tissue and around damaged trabeculae at eighteen days, and leucocytes invade the fibrinous track lining. At twenty-four days, organisation of the outer (deeper) layer of the lining is seen, and there is much apposition of new bone to old trabeculae. At eight weeks the lining of the tunnel has become fibrous; collagen fibres and new bone tend to be orientated in the long axis of the tunnel. In Cases 6, 7 and 8 from eleven to thirteen weeks

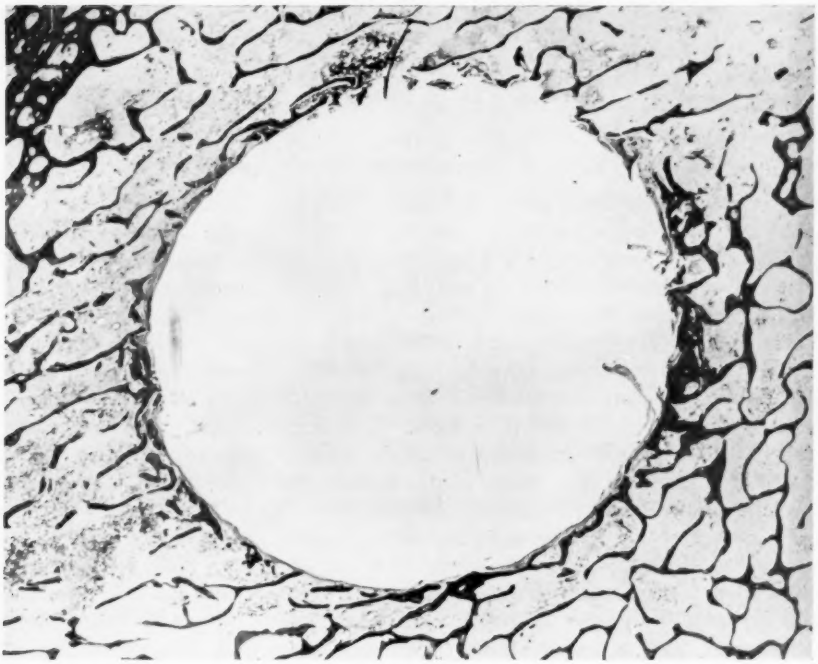

FIG. 5

Case 6—Cross-section of tunnel in cancellous bone of femur eleven weeks after insertion of plastic prosthesis. Part of the fibrous lining has been torn away in preparing the section. Early bone sclerosis, mainly by apposition of new bone to old trabeculae, can already be seen in some parts of the wall. (H. and E. × 5·8.)

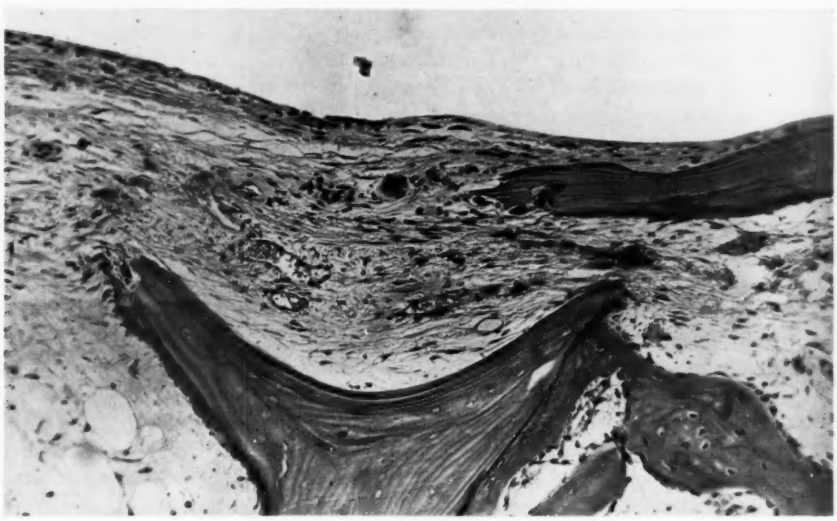

FIG. 6

Detail of section shown in Figure 5. The wall of the cavity eleven weeks after operation is of fibrous tissue. New, coarse-fibred bone has been applied to the right-hand border of the old Y-shaped trabecula. Another old trabecula lies near the surface, and osteoblasts are beginning to add bone to its under side. The fractured ends of the original trabeculae show osteoclastic resorption. The osteogenic repair tissue is still highly vascular and there are a few leucocytes. (H. and E. × 110.)

after operation, various degrees of consolidation of the new fibrous and bony wall can be observed (Fig. 6).

Neither the presence of mild sepsis (Case 1) nor the infiltration of some marrow spaces by metastatic bronchial carcinoma (Case 5) seemed to influence the vigour of the repair reaction.

DISCUSSION

The study of these cases shows that up to three months after operation the intact methyl-methacrylate implant is harmless to the tissues. Nothing indicates that there has been an irritating or toxic influence. The pattern of repair and reconstruction of the bone around the plastic implant is identical with that seen around non-corrodible stainless steel nails, which I have described in detail elsewhere (Collins 1953*a*). I was able to study nail-containing bones up to five years after operation and to formulate a rough guide to the time at which certain phases of repair develop. Organisation of effused blood can be observed at five days, and a continuous fibrous sheath lining the tunnel at five weeks. By five months an incomplete shell of new bone has formed in the fibrous wall, and by five years the bony wall has developed into a true cortex of normal lamellar bone covered with periosteum (Collins 1953*b*). Only the early stages of this sequence have been observed in the present study. No special reaction to the plastic material is seen. Granulation tissue and new bone form as expected, there is no excessive leucocyte reaction, and no foreign body giant cells appear. Scales (1953) illustrated the foreign body granulomatous reaction that may occur around shattered and finely abraded polythene, in contrast with the bland fibrosis that develops around the intact polythene rod. Fracture and comminution of the plastic appliance might, therefore, lead to a different sort of tissue reaction from that seen in the present series. Obviously no conclusions can be drawn from the present study regarding the long-term effects of burying plastics in bone.

Laing and Ross (1952) described the changes in the femoral neck in contact with an acrylic prosthesis in a case fourteen days after operation. They interpreted some of the changes as necrotic and illustrated others that are regenerative. There was no reason to blame the acrylic material for any of the changes, for at fourteen days after a fracture—in this case a deliberate amputation of the neck of the bone—necrosis, resorption and regeneration of the bone ends commonly occur on a considerable scale. Nor can the nature of the material be blamed for the absorption of the neck and the sinking of the prosthesis that are sometimes seen in serial radiographs after the operation. These events are the result of the bone's being unable to reconstruct itself quickly enough or in such a way as to maintain equilibrium with the new mechanical forces imposed upon it. When the operation has been performed for fracture of the femoral head or neck, it is often the case that the bone is osteoporotic and, although the appearance of callus and repair tissues is not delayed, the newly formed bone is deficient in collagen and may fail to form a consolidated system of trabeculae. Permeation of the bone by metastatic new growth, invisible on radiographic examination as in Case 5, is also a possible cause of progressive collapse of the root of the neck.

Acceptable evidence that the inserted material was noxious would be: 1) osteolysis around the buried prosthesis in the generality of cases; 2) interference with the processes of repair, manifest either by a primary failure of granulation tissue to organise the effused blood or by a later failure of collagenisation and osteogenesis; and 3) histological evidence of inflammation and granuloma formation around the implanted material. In the case of methyl-methacrylate Judet prostheses inserted into human femurs, none of these signs has been observed in any patient up to thirteen weeks after operation. There is good reason for supposing the material to be inert, so long as the appliance remains intact, and for assuming that the final accommodation of the plastic peg in the bone will be similar to that already observed up to five years after operations in which stainless steel nails have been inserted.

It is important to realise that, although biologically inert, an implanted object, whether stainless steel or plastic, never becomes incorporated into the bone. It remains a foreign body sequestrated from the inner structure of the bone by the wall of tissue, first fibrous and later both fibrous and bony, that is built around it. Should the nail or peg be cleanly withdrawn in later years, there remains a bone that is intact, although deformed, for the socket wall comes to be lined by new periosteum overlying a new cortex, as much the true surface of the bone as though the new cortex and new periosteum had arisen by an actual invagination.

SUMMARY

1. A pathological study has been made of eight femurs containing acrylic Judet type prostheses, in patients who had died two to thirteen weeks after arthroplasty.
2. Haemorrhage occurs into the tunnel and into a limited zone of the spongy bone around the tunnel. Organisation of the blood clot is evident at two weeks and new bone formation appears shortly afterwards. At eight weeks the tunnel is lined by a fibrous membrane. Further fibrosis and new bone growth tend to establish a new surface, healing the wound in the bone and sequestrating the foreign body.
3. There is no evidence that the intact methyl-methacrylate appliance had exerted any toxic action on the tissues.

I wish to thank my colleagues in the Orthopaedic and Pathological Departments of the General Infirmary and of St James's Hospital, Leeds, and Mr F. W. Holdsworth of Sheffield, who operated in Case 8, for enabling me to obtain information and material. Mr C. N. England kindly made the photographs.

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THE NATURE OF THE BONE CHANGES ASSOCIATED WITH NERVE INJURIES AND DISUSE

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It is well known that bone atrophies after certain nerve lesions and as a result of disuse. The change may be due to loss of some specific neurotrophic influence or, perhaps, to loss or alteration of its normal function. The nature of the so-called atrophy has not been thoroughly investigated; in particular, previous work has not established whether it is due to an alteration in the quality or merely to a reduction in the quantity of bone. Part of the difficulty in understanding the mechanism involved is—as Howard (1945) remarked in discussing the effect on the skeleton of injuries of the spinal cord—that we are still ignorant of the true circumstances or stimuli that induce bone formation or absorption. " If the fundamental stimulus active in bone absorption were known, it might be possible to prevent bone atrophy during disuse."

Previous experimental work has been concerned chiefly with the effects of nerve lesions and disuse on the form of the affected bones, and, with some exceptions (Allison and Brooks 1921), little attention has been paid to the quality of the bone.

This paper describes experiments made to study the changes occurring in the physical properties of the bones of a limb after section of its anterior or posterior nerve roots or peripheral nerves. Since it could be claimed that bone has been " designed " for the support of the body, the properties and quality of the bones were estimated in much the same way as supporting structures are investigated by engineers or bridge builders, rather than by histological or chemical methods. The attitude adopted was that the strength of the skeleton is of primary importance to the animal, and that histological or chemical details are of secondary importance as revealing only how this strength is achieved.

METHODS

Experimental animals—Kittens, on reaching a weight of 750 to 1,200 grammes, were subjected to laminectomy under general anaesthesia produced by intraperitoneal pentobarbitone and open ether. The hind limb of the cat derives its somatic nerve supply from the fifth lumbar to the first sacral segments of the spinal cord, with small contributions from the fourth lumbar and the second sacral segments. At operation either the anterior or posterior nerve roots of the fifth lumbar to the first sacral segments were divided on one side. The normally innervated limb acted as a control.

Twenty-eight kittens were divided into three groups. In the first group, consisting of ten kittens, the anterior nerve roots were divided. In the second group of ten kittens the posterior nerve roots were divided. In a third group of kittens lumbar sympathectomy was carried out on the same side, and at the same time, as anterior nerve root section, in order to investigate the possibility that changes in the bones might be due in part to a deficient blood supply. All the lumbar ganglia from the level of the renal vein to the pelvic brim were removed extra-peritoneally.

The kittens lived in a large run, which allowed plenty of exercise, and were fed on a generous diet of fish, milk, porridge, and " Kit-E-Cat," supplemented by veterinary cod liver oil. A number of the kittens were maintained in the ideal conditions of the animal house at the Royal Free Hospital Medical School, London. All the animals operated upon there survived in excellent condition for the period of the experiment.

The kittens were killed two months after operation. The hind limbs were dissected free, skinned, and weighed, after which the femora, tibiae and fibulae were carefully cleaned, and exposed to the air for several weeks at room temperature before being subjected to the various tests described below. In this way all the bones had approximately the same moisture content. The muscle groups of each hind limb were weighed separately as they were removed.

In addition, experiments were made on sixteen young, white, male rats, weighing approximately 120 grammes, one hind limb being paralysed by avulsion, under ether anaesthesia, of the femoral and sciatic nerves. The animals were fed liberally on rat cake, which supplied a complete diet, and were killed four weeks after operation. The femora and tibiae were removed, cleaned, and allowed to dry.

Examination of the bones—All the bones were weighed. The femora of both kittens and rats were subjected to bending tests to allow the measurement of the bending moment, breaking stress, and Young's modulus of elasticity. The method of carrying out these tests has been fully described elsewhere (Bell, Cuthbertson and Orr 1941, Weir, Bell and Chambers 1949). The specific gravity of a piece of cortex from the middle of the front of the shaft of each kitten femur was measured by weighing in air and in water, a small quantity of aerosol-T being added to the water to eliminate the air bubbles which otherwise clung to the bone surfaces. The rat tibiae were dried overnight at 100 degrees Centigrade, weighed, and then ashed to constant weight in a muffle furnace at a temperature of 600 degrees Centigrade. Densitometric readings were made at three selected points on the radiograph of each rat femur, all the femora being photographed on one film, and an average value obtained for the bone. The lengths of the kitten femora and tibiae were measured from radiographs taken at a standard tube-target distance of six feet.

RESULTS

Condition of the animals after operation—After anterior nerve root section the kittens were very active, almost from the day following operation. They gave no indication that their paralysed limbs were any handicap, running, playing and climbing well on three legs, keeping themselves clean and eating heartily. Without exception the kittens after anterior nerve root section gained weight steadily, apart from a slight fall in the day or two after operation. At first the paralysed limb was dragged behind the animal, but about a week after operation there was slight recovery of tone in the muscles of some of the kittens and they began to make feeble movements with the limb during walking. In these cases the dorsum of the paw was placed on the ground, the pads being directed upwards. In spite of this no trophic ulcers developed in the paralysed limb of any of these kittens. Muscle wasting was soon apparent. It progressed rapidly, so that at the end of the experiment the muscles of the paralysed limb weighed only about half as much as those of the normal limb, the reduction in weight affecting all the muscle groups.

Quite a different picture was presented by most of the kittens in which posterior nerve root section had been carried out. After operation these animals were unhappy, were not interested in their food, and gained weight only very slowly. Indeed, some had scarcely regained their pre-operative weight a month later. The anaesthetic limb gave them considerable trouble in the week or so after operation, being carried pointing stiffly towards the opposite front paw, rubbing along the ground. This appeared to reduce their desire to move about, and undoubtedly contributed to their disinclination to feed. Later, the animals changed to dragging the affected limb behind them, and it gave much less trouble, though they did not indulge in climbing or in much playing. Within three to four weeks ulcers developed on nearly all the anaesthetic limbs, where the fur was rubbed off in dragging the limbs along the ground, and these were covered with protective bandages for the rest of the experimental period. Muscle wasting did not occur in these limbs, in spite of the heavy bandaging, and despite the fact that they were dragged, and moved very little. The kittens

after this operation appeared to be more susceptible to infection than the kittens in the other groups, this undoubtedly being a reflection of their general condition. When the weights of the muscle groups of the operated and normal limbs were compared they were found to be almost the same in all cases (Table I). Samples of spinal cord were stained to show the degeneration in the posterior white columns after posterior nerve root section.

The kittens in which unilateral lumbar sympathectomy was added to anterior nerve root section could not be distinguished from those with anterior root section alone in regard to activity, weight gain, and extent of muscle wasting. After sympathectomy the pads were warmer to the touch, and lightly pigmented pads were much pinker. Pad temperature recordings, made as a check on the effectiveness of the sympathectomy, showed a persistently higher temperature on the operated side throughout the experimental period of two months. It was found that after the first few weeks the difference in temperature between the pads of the normal limbs and those operated upon, originally 2 to 6 degrees Centigrade at ordinary room temperature, became less; but if the limbs were exposed to cold for a few minutes immediately before taking the temperatures the difference was greatly increased. This

TABLE I

COMPARISON OF MUSCLE WASTING AFTER ANTERIOR AND POSTERIOR NERVE ROOT SECTION

Total weight of the quadriceps, adductors, hamstrings and tibialis anterior and posterior muscles of the limb operated upon has been expressed as a percentage of the weight of these muscles of the normal limb for each kitten.

Group	Number of kittens	Mean percentage
1. Anterior nerve root section . .	10	59
2. Posterior nerve root section . . .	10	103
3. Anterior root section plus sympathectomy	8	56

illustrates well the difference in the vascular adjustment of the two limbs, reflex vasoconstriction on cooling being absent on the side of the sympathectomy. At post-mortem examination there were no visible signs of regeneration of the sympathetic chain in any of the animals.

The rats were little upset by the avulsion of the femoral and sciatic nerves of one limb, the affected limb being carried tucked up under the abdomen, and in no case was any attempt made to use it. Several of the animals, however, chewed off large parts of their anaesthetic, paralysed limbs and were destroyed.

Examination of the bones—The physical properties of the kitten bones are recorded in Table II and analysed in Table III. Anterior nerve root section in the first group of kittens resulted in a significant reduction in the weight, cortex thickness, and bending moment of the bones of the paralysed limb. The breaking stress, Young's modulus of elasticity, and the specific gravity showed no change. Similar results were obtained for the bones of the third group of kittens, in which lumbar sympathectomy was added to the anterior nerve root section, except in regard to the breaking stress, which was slightly, but significantly, reduced on the side operated upon. The bones of the second group of kittens, which were subjected to posterior nerve root section, showed no significant difference between the limbs operated upon and the normal limbs in any of the physical properties considered.

Table IV records the physical properties of the rat bones, and these results are analysed in Table V. The weight, ash weight, ash percentage, bending moment, breaking stress, and

TABLE II

THE PHYSICAL PROPERTIES OF THE KITTEN BONES

Group	Kitten	Weight of femur (*g.*)		Weight of tibia and fibula (*g.*)		Bending moment at breaking point (*lb. in.*)		Breaking stress ($lb.\ in.^2 \times 10^3$)		Young's modulus ($lb.\ in.^2 \times 10^6$)		Specific gravity of cortex sample		Mean cortical thickness of femur (*in.*)	
		Denervated limb	Normal limb	Denervated limb	Normal limb	Denervated limb	Normal limb	Denervated limb	Normal limb	Denervated limb	Normal limb	Denervated limb	Normal limb	Denervated limb	Normal limb
1	G2	2·94	3·31	2·68	3·31	—	—	—	—	—	—	—	—	0·024	0·031
	G3	3·09	3·21	3·05	3·28	—	—	—	—	—	—	—	—	0·030	0·032
	G4	2·24	3·17	2·16	3·20	—	—	—	—	—	—	—	—	0·026	0·033
	G5	2·04	2·95	2·03	3·00	—	—	—	—	—	—	—	—	0·020	0·031
	G8	2·24	2·96	2·16	3·15	—	—	—	—	—	—	—	—	0·025	0·035
	4	3·94	4·66	4·08	5·11	39·52	48·02	34·1	35·8	1·83	1·82	1·91	1·88	0·035	0·045
	5	3·26	3·91	3·09	3·89	37·21	48·31	42·9	40·0	2·46	2·16	2·02	2·00	0·032	0·041
	9	3·33	4·38	3·16	4·21	37·87	50·58	43·3	39·6	2·72	2·02	2·04	1·92	0·033	0·046
	10	3·92	4·23	4·02	4·37	46·82	49·38	39·7	36·2	2·06	1·89	1·92	1·87	0·040	0·041
	15	3·25	3·91	2·96	3·89	39·16	48·89	34·8	38·2	2·00	2·22	2·05	2·05	0·033	0·039
2	G12	2·55	2·48	2·55	2·49	—	—	—	—	—	—	—	—	0·033	0·026
	G14	4·57	4·13	4·60	4·28	—	—	—	—	—	—	—	—	0·042	0·036
	G15	3·72	3·43	3·44	3·39	—	—	—	—	—	—	—	—	0·032	0·031
	G16	3·91	3·65	3·88	3·73	—	—	—	—	—	—	—	—	0·035	0·033
	16	4·34	4·38	4·64	4·49	54·80	52·16	44·9	41·1	2·23	2·38	2·03	2·05	0·034	0·033
	19	1·72	1·75	1·56	1·71	18·48	19·09	31·1	33·0	1·96	2·32	1·96	2·03	0·026	0·025
	20	1·79	1·76	1·75	1·69	19·18	19·05	32·9	32·0	1·77	1·85	1·97	1·97	0·024	0·023
	21	4·30	4·43	4·07	4·33	27·09	30·35	37·5	35·1	2·18	1·97	2·05	1·95	0·029	0·032
	H8	5·27	5·24	5·44	5·19	60·48	60·97	42·7	43·5	2·14	2·60	1·91	1·91	0·046	0·046
	H9	5·07	5·15	5·34	5·16	53·84	55·50	43·7	42·9	2·78	2·00	1·99	1·95	0·048	0·046
3	R7	4·05	5·24	3·78	5·74	31·46	55·87	38·0	44·8	2·52	2·18	1·90	2·19	0·036	0·051
	R8	4·83	5·73	4·43	5·93	42·67	51·98	40·2	41·3	2·18	2·29	1·79	1·80	0·049	0·054
	R9	3·56	4·16	3·56	3·82	27·84	51·80	36·2	47·4	2·54	1·97	1·88	1·90	0·040	0·046
	R10	3·17	4·45	2·90	4·46	25·77	45·00	31·3	43·5	2·07	2·58	1·91	1·82	0·040	0·049
	P10	4·81	6·11	4·72	6·34	49·14	65·62	40·1	42·2	2·37	1·62	1·91	2·16	0·044	0·052
	P11	4·50	5·61	4·53	5·90	48·42	60·69	39·1	47·6	2·23	3·01	1·99	1·84	0·051	0·047
	P12	4·22	4·52	4·07	5·65	34·11	55·48	41·8	45·2	2·46	2·24	1·90	1·96	0·048	0·053
	P14	5·44	6·26	5·10	6·21	48·64	69·69	38·8	46·8	2·27	1·91	1·97	1·87	0·045	0·052

radiographic density were all significantly less for the bones of the denervated limb, while Young's modulus of elasticity was unaltered.

Samples of bone were retained for x-ray crystallography, the results of which will be reported later.

DISCUSSION AND CONCLUSIONS

After the bony changes resulting from paralysis have been noted it is proposed to consider two questions: What is the nature of the changes occurring in a limb bone after nerve lesions

TABLE III

COMPARISON OF THE PHYSICAL PROPERTIES OF THE BONES OF THE NORMAL AND DENERVATED KITTEN LIMBS

Bone property	Group	Greater on	Percentage difference	Mean difference	P	Remarks
Weight of femur	1	Normal side	17·6	0·64 g.	<0.001	Highly significant
	2	Denervated side	2·3	0·08 g.	>0.05	Not significant
	3	Normal side	17·9	0·81 g.	<0.001	Highly significant
Weight of tibia and fibula	1	Normal side	21·5	0·70 g.	<0.001	Highly significant
	2	Denervated side	0·5	0·08 g.	>0.05	Not significant
	3	Normal side	25·6	1·37 g.	<0.001	Highly significant
Bending moment at breaking point	1	Normal side	17·9	9·12 lb. in.	<0.05	Significant
	2	Normal side	1·3	0·54 lb. in.	>0.05	Not significant
	3	Normal side	32·4	18·51 lb. in.	<0.001	Highly significant
Breaking stress	1	Denervated side	2·8	$1{\cdot}00 \times 10^3$ lb. in.^{2}	>0.05	Not significant
	2	Denervated side	2·3	$0{\cdot}87 \times 10^3$ lb. in.^{2}	>0.05	Not significant
	3	Normal side	14·9	$6{\cdot}66 \times 10^3$ lb. in.^{2}	<0.05	Significant
Young's modulus	1	Denervated side	9·3	$0{\cdot}19 \times 10^6$ lb. in.^{2}	>0.05	Not significant
	2	Normal side	0·5	$0{\cdot}01 \times 10^6$ lb. in.^{2}	>0.05	Not significant
	3	Denervated side	4·7	$0{\cdot}09 \times 10^6$ lb. in.^{2}	>0.05	Not significant
Specific gravity	1	Denervated side	2·2	0·044	>0.05	Not significant
	2	Denervated side	0·5	0·008	>0.05	Not significant
	3	Normal side	1·9	0·036	>0.05	Not significant
Cortical thickness of femur	1	Normal side	20·4	0·0073 in.	<0.05	Significant
	2	Denervated side	5·2	0·0018 in.	>0.05	Not significant
	3	Normal side	11·3	0·0051 in.	<0.05	Significant

and disuse? And are these changes due to direct loss of some specific neurotrophic influence, or are they due to muscular inactivity?

The nature of the bone changes—The results of the kitten and rat experiments, in conjunction with clinical observations, allow some general conclusions to be made regarding the bony changes after paralysis. In this discussion the term paralysis refers throughout to the result of a lower motor neurone lesion. In a paralysed limb the weight of the bones is greatly reduced. The reduction in weight amounted to over 20 per cent in these experiments, and similarly the ash weight, the bending moment at breaking point and the

TABLE IV

THE PHYSICAL PROPERTIES OF THE RAT BONES

Rat	Weight of femur (*mg.*)		Weight of tibia (*mg.*)		Ash weight of tibia (*mg.*)		Percentage ash of tibia		Bending moment at breaking point (*lb. in.*)		Breaking stress ($lb.\ in.^2 \times 10^3$)		Young's modulus ($lb.\ in.^2 \times 10^6$)		X-ray density	
	Denervated limb	Normal limb	Denervated limb	Normal limb	Denervated limb	Normal limb	Denervated limb	Normal limb	Denervated limb	Normal limb	Denervated limb	Normal limb	Denervated limb	Normal limb	Denervated limb	Normal limb
1	330	432	209	265	116	153	55·5	57·7	2·64	3·81	25·4	33·4	2·36	2·56	0·51	0·39
2	338	447	223	265	122	158	54·7	59·6	2·81	4·03	28·6	25·2	2·67	1·73	0·54	0·43
3	391	499	235	308	136	179	57·9	58·1	3·06	4·52	23·3	29·8	1·72	1·87	0·52	0·44
4	289	400	195	243	106	139	54·4	57·2	1·67	3·43	18·4	30·4	2·51	2·21	0·59	0·49
5	373	436	229	269	128	152	55·0	56·5	3·17	3·86	32·0	31·0	2·96	2·60	0·56	0·50
A1	272	368	208	262	128	161	61·5	61·5	2·94	4·22	29·4	33·7	2·11	2·27	0·41	0·32
A2	273	399	229	279	139	175	60·7	62·7	2·80	3·54	30·1	34·0	2·53	2·53	0·38	0·29
A3	284	385	222	278	132	171	59·5	61·5	2·70	3·89	29·1	34·6	2·97	2·56	0·38	0·27
A4	218	339	176	225	106	138	60·2	61·5	2·88	3·75	30·2	32·6	1·95	1·81	0·38	0·28
A5	278	374	187	260	113	158	60·4	60·8	2·71	4·26	25·6	35·9	2·01	2·77	0·38	0·27
A6	272	389	204	269	116	158	56·9	58·7	1·99	3·80	22·0	32·6	2·26	2·18	0·42	0·32
A7	229	337	189	235	112	148	59·3	63·0	2·36	3·22	33·3	32·8	2·50	2·28	0·40	0·30
A8	287	424	215	294	128	179	59·5	60·9	2·54	3·70	24·6	29·4	2·15	2·58	0·36	0·28
A9	225	296	166	199	100	120	59·6	60·3	2·48	3·14	27·3	30·3	1·62	2·08	0·38	0·31

TABLE V

COMPARISON OF THE PHYSICAL PROPERTIES OF THE BONES OF THE NORMAL AND PARALYSED RAT LIMBS

Bone property	Greater on	Percentage difference	Mean difference	P	Remarks
Weight of femur	Normal side	26·9	105·4 mg.	$<0·001$	Highly significant
Weight of tibia	Normal side	20·8	54·6 mg.	$<0·001$	Highly significant
Ash weight of tibia . . .	Normal side	23·2	36·4 mg.	$<0·001$	Highly significant
Percentage ash of tibia . .	Normal side	3·0	1·76%	$<0·001$	Highly significant
Bending moment at breaking point	Normal side	30·8	1·17 lb. in.	$<0·001$	Highly significant
Breaking stress	Normal side	14·4	$4·74 \times 10^3$ lb. in.^{2}	$<0·05$	Significant
Young's modulus . . .	Denervated side	2·1	$0·02 \times 10^6$ lb. in.^{2}	$>0·05$	Not significant
X-ray density	Normal side	21·9	0·09	$<0·001$	Highly significant

x-ray density were reduced by the same amount. The thinning of the bones of a paralysed limb is well known; it affects the shaft chiefly, the epiphyses thus giving the appearance of being increased in width. When the femur of a paralysed limb is divided at some point in the shaft the section is seen to be rounder than that of a normal femur. The intrinsic forces of bone tend to produce a rounded section, while the extrinsic forces normally present modify this to a more angular form. Although the reduction of width affects both the cortex and the meduallary cavity the reduction in cortical width is relatively greater. In the kitten experiments the width of the medullary cavity of the femora of the paralysed limbs amounted to 74 per cent of the external diameter of the shaft, whereas the ratio was 69 per cent in the femora of the normal limbs. At the same time the average cortical thickness was significantly diminished in the femora of the paralysed limbs. Growth in length of the bones was not significantly altered by paralysis in the period of these experiments—that is, epiphysial growth was not affected nearly to the same extent as appositional growth. Over a longer period, of course, growth in length of the paralysed limb bones lags far behind that of the normal limb bones, as is well seen in the paralysis resulting in children from anterior poliomyelitis. The union of epiphyses is little delayed by paralysis, though in the cleaning of the rat bones the lower femoral or upper tibial epiphysis became detached in a few cases, always on the paralysed side. The strength of a paralysed limb bone as a whole is greatly reduced, as was shown by the large reduction of the bending moment needed to break the bone in both rats and kittens.

The addition of lumbar sympathectomy, in the kittens, did not alter the bony changes resulting from paralysis except in regard to the breaking stress (*vide infra*). These changes cannot, therefore, be primarily due to a diminution of the blood supply, since an improvement in this does not prevent their occurrence. The bony changes following peripheral nerve section in the rats were similar to those resulting from anterior nerve root section except, again, in regard to the breaking stress.

The highly significant reduction in the total weight, ash weight, x-ray density and bending moment, in the bones of paralysed limbs, could be due either to a loss of mineral from the matrix—that is, to a change in the quality of the bone—or to a diminution in the total quantity of bone, the matrix-to-mineral ratio remaining unaltered. Such a diminution in bone quantity might result either from a reduction in the external dimensions and cortical thickness of the bone or from an increase in the porosity of the cortex from enlargement of the Haversian canals. Whether the change is one of quality or quantity can be ascertained only by reference to tests of bone quality which give results in terms of a unit volume of bone, such as the ash percentage, breaking stress, elasticity, and specific gravity. The ash percentage of the paralysed limb bones was found to be constantly lower than that of the normal limb bones by 1 or 2 per cent but, although highly significant statistically, it is a relatively small change. The experimental work did not yield consistent results in regard to the effect of paralysis on the breaking stress, this being significantly reduced in the third group of kittens and in the rats, but unaltered in the first group of kittens. Young's modulus of elasticity of the femora was not significantly altered by paralysis in either the kittens or rats. The specific gravity of the samples of the femoral cortex was unaltered, and this excludes an increase in cortical porosity.

From the results of the present experiments it may be said that, although bone quality is altered by paralysis, the alteration is small, and the marked changes occurring in the bones of paralysed limbs are almost entirely due to a reduction in the quantity of bone. This bears out Abramson's (1948) belief that in the similar condition of disuse atrophy of bone there is no interference with calcium deposition into the bone matrix, but that the laying down of the matrix itself is deficient.

Cause of the bone changes—The second question, regarding the cause of these bony changes, remains to be considered. Nerves have long been believed to exert some trophic action on

bone, the loss of which leads to bone atrophy (Nasse 1880), though it was soon recognised that disuse alone played an important part in the production of bone atrophy. However, the idea of a neurotrophic influence is still widely held, it being stated in the current edition of a standard text-book of pathology (Cappell 1951) that the change in the bones occurring after paralysis " may in part be the result of disuse, but there seems to be little doubt that it is largely a trophic effect." The difficulty in trying, experimentally, to separate, and to differentiate between, the effects of purely nervous and purely muscular influences on bone is that the function of the muscles depends on the integrity of the nerves, so that any interference with the latter at once leads to changes in the former; and, conversely, it is impossible to detach the muscles completely from a bone without interfering with its vascular and nerve supply. One way round this difficulty is to compare the effects of disuse produced in a number of different ways, as was done by Grey and Carr (1915), by Pottorf (1916), and by Allison and Brooks (1921). These workers compared the bony atrophy occurring in disuse produced by nerve section and by immobilisation. The general finding was that the atrophy was similar in both cases, but that its rate of onset, and its final extent, depended on how great was the degree of disuse obtained.

Some recent clinical findings are relevant to this question. It is well known from observation of children suffering from paralysis of one lower limb, following acute anterior poliomyelitis, that the bones of the affected limb become progressively shorter than those of the normal limb. The diminution in growth cannot, however, be expressed as an exact percentage per year. This problem has been investigated by Stinchfield, Reidy and Barr (1949). After a survey of 166 adult patients in whom one lower limb had been paralysed before the age of eleven years, they stated that there was no specific relationship between the age of onset of the paralysis and the extent of the final discrepancy in limb lengths, but that there was a definite relationship between the relative muscle strengths of the two limbs and the discrepancy in limb lengths. Gullickson, Olson and Kottke (1950) investigated eighty-eight patients in whom paralysis of one lower limb had occurred from poliomyelitis three to seven years previously when all the patients were under fourteen years of age. Like Stinchfield *et al.* (1949), they found that there was a close correlation between the relative muscle power of the two limbs and the extent of the shortening of the paralysed limb. The final discrepancy in limb lengths depends greatly on how much the limb is used, and it has been shown in the management of children with one paralysed limb that education in the performance of exercises designed to increase the use of the limb to the greatest possible extent may lead to a marked reduction of the discrepancy in growth.

In consideration of these clinical observations, it seemed important to determine how far the extent of muscle atrophy could be correlated with bone atrophy in the paralysed limbs of experimental animals in which the bones and muscles can actually be weighed. The weights of the femur, tibia and fibula were totalled on each side in all the kittens in which anterior nerve root section had been carried out, including those with a superadded sympathectomy. The combined weight of the bones of the paralysed limb was then expressed as a percentage (y) of the combined weight of the bones of the normal limb. Similarly, the total weight of the skinned paralysed limb was expressed as a percentage (x) of the total weight of the skinned normal limb. The two values, x and y, when plotted (Fig. 1) show the strong correlation between muscular wasting and bony atrophy.

Statistical analysis gives the following results.

$\bar{y}=79{\cdot}2$ S.D.$_y=6{\cdot}9$ S.D.$_{\bar{y}}=1{\cdot}6$

$\bar{x}=64{\cdot}4$ S.D.$_x=11{\cdot}7$ S.D.$_{\bar{x}}=4{\cdot}8$

The coefficient of correlation of y and x is $+0{\cdot}79$, with $t_{16}=5$ ($P=_{16}0{\cdot}001$), which is highly significant. This yields a regression equation of $y=0{\cdot}46x+50$ with a standard error of estimate of $y=7{\cdot}2$. This is illustrated in Figure 1.

It will be noted that the "scatter," as expressed by the standard deviation, is greater in the muscle values than in the bone. The difference between the two standard deviations is 4·8, which has a standard error of 1·52, so that the ratio of the difference to its standard error is 3·1, which is significant.

After posterior nerve root section the kittens were unable to make co-ordinated use of their limbs for purposeful movements and therefore moved them very little, but muscle tone was retained and muscle wasting did not occur. This proved to be sufficient to prevent bone atrophy, for the physical tests showed no bone changes after this operation. That is, normal functional activity is not essential for the prevention of bony atrophy provided muscle tone is retained.

When the highly significant correlation between muscle and bone atrophy is considered in conjunction with the fact that there is no histological evidence that any fibres from the anterior horn cells of the spinal cord enter bone (de Castro 1925, 1930, Hurrell 1937, Corbin and Hinsey 1939), and that bone atrophy resulting from disuse, with the motor nerves intact, is exactly similar to that occurring in paralysis, it seems to be conclusively

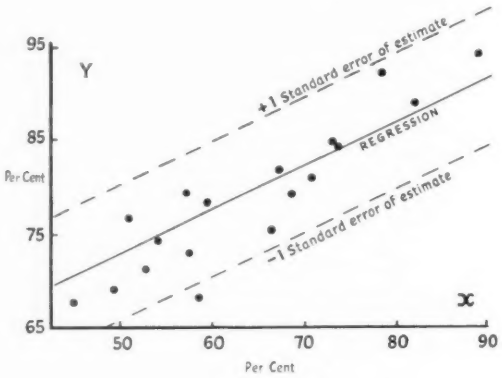

FIG. 1

Correlation of "denervated" bone and muscle weights as percentages of normal weights.

The combined weight of the femur, tibia and fibula of the paralysed limb has been expressed as a percentage (y) of the combined weight of these bones of the normal limb. The total weight of the skinned paralysed limb has been expressed as a percentage (x) of the weight of the normal limb. The figure shows the regression of y on x, with control limits of + or −1 standard error of estimate, for sixteen kittens, in each of which one lower limb had been paralysed by anterior nerve root section.

proved that bone atrophy, or diminished growth, in paralysed limbs is due entirely to loss of muscular power and tone, and hence disuse, and not to loss of any specific neurotrophic influence.

SUMMARY

1. Paralysis caused by anterior nerve root section, or by peripheral nerve section, leads to marked changes in the bones and muscles of the affected limb in experimental animals. Vascular changes are not the cause of the bone atrophy in a paralysed limb.

2. The altered properties of the bones of a paralysed limb are due almost entirely to a loss in the quantity of bone; bone quality is only slightly altered.

3. The bone changes that follow paralysis are due to the secondary loss of muscular activity. No evidence could be obtained that nerves exert any specific, trophic influence on bone.

I am greatly indebted to Professor G. H. Bell for his continuous interest and advice in the preparation of this paper. He has also allowed me to incorporate the results of a few experiments carried out with Mr J. S. Robertson. I wish to acknowledge the kindness of Professor E. M. Killick and Mrs P. P. Scott, of the Royal Free Hospital Medical School, London, for allowing me to do part of the experimental work in their

laboratory. Dr E. P. Smith gave valuable advice on the statistics. Part of the apparatus used was purchased out of a grant from the Medical Research Council to Professor Bell. The work was carried out while I held a Carnegie Trust Research Scholarship, which I gratefully acknowledge.

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HISTOCHEMICAL STUDIES OF BONE IN NORMAL AND PATHOLOGICAL CONDITIONS

With Special Reference to Alkaline Phosphatase, Glycogen and Mucopolysaccharides

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The histological investigation of phosphatase localisation (Gomori 1939, Takamatsu 1939), and especially the methods which allow decalcification of hard tissues without causing any appreciable loss of the enzyme (Lorch 1947, Greep, Fischer and Morse 1948, Zorzolli 1948), mark important progress in the study of ossification. The work carried out in normal growing bone, in fractures and in a few pathological processes (Kabat and Furth 1941, Gomori 1943, McKelvie and Mann 1948, Follis and Berthrang 1949, Lorch 1949, Follis 1950, Majno and Rouiller 1951), confirms the relationship of phosphatase activity to calcification and ossification.

Follis (1949) correlated the qualitative observations obtained by histochemical techniques and the quantitative chemical determination of enzyme activity in the normally differentiating costal cartilage, providing confirmation for the histochemical results.

Gutman *et al.* (1950) insisted on the importance of glycogen in calcification of epiphysial cartilage. This substance, which is very plentiful in hypertrophic cartilage, disappears abruptly when the cartilage becomes calcified. On the other hand a great number of enzymes and intermediate substances resembling those recognised in the anaerobic glycogenolysis cycle of muscle have been isolated in this zone. For Gutman's group, the phosphatase would intervene only indirectly in the calcification process.

Sylvén (1947), using metachromatic techniques specific for the acid mucopolysaccharides (Lison 1936), showed a loss of metachromasia in calcified cartilage and bone. Rubin and Howard (1950) supposed that this loss was caused by the union of the mucopolysaccharide (especially the chondroitin sulphuric acid) with the calcium. However, by using weak acids such as lactic acid, it is possible not only to return the metachromasia to the calcified zones but even to increase it. It is evident (Sylvén 1947, Rubin and Howard 1950, Moog and Wenger 1952) that the cartilage zones that are in process of calcification undergo some changes in their mucoproteic support, and perhaps these alterations play an important role in the process of precipitation of calcium salts.

To prove and determine the importance of alkaline phosphatase and its relation to glycogen and the acid mucopolysaccharides (metachromatic substances) we have made an exhaustive study of these substances in normal ossification (enchondral and membranous) in rats, mice and men, comparing the normal with the pathological in a series of forty cases which included the principal tumoral and dystrophic processes that are found in bone.

The only paper which mentioned briefly alkaline phosphatase studies in bone tumours is that of Gomori (1943) who studied four osteogenic sarcomas, two giant-cell tumours, two fibrosarcomas and one case of metastatic carcinoma in bone.

The alkaline phosphatase was demonstrated by using different times of incubation and diverse substrates (Dempsey and Deane 1946) which enabled us to see variations in intensity and localisation which have not been studied hitherto.

MATERIAL AND TECHNIQUE

For studying the normal process of ossification we used the fore and hind limbs and the heads of mice and rats aged two weeks, and also the ossifying zones in resected specimens from young people.

The pathological material studied is shown in Table I.

TABLE I

PATHOLOGICAL MATERIAL

	Number of cases
Dystrophic disorders	
Paget's disease	4
Fibrous dysplasia	1
Bone cyst	1
Eosinophilic granuloma	1
Benign tumours	
Chondroma	4
Osteochondroma	4
Osteoid osteoma	1
Giant-cell tumour of bone (one with sarcomatous transformation)	5
Giant-cell tumour of synovial membrane	4
Malignant tumours	
Osteogenic sarcoma	1
Chondrosarcoma	5
Myeloma	2
Ewing's sarcoma	1
Sarcomatous transformation of Paget's disease	1
Liposarcoma	1
Metastasis from carcinoma	4

The legs and heads of the mice and rats were fixed in formalin (10 per cent solution), alcohol (80 per cent solution), acetone and Rossman's fluid; the three last mentioned were used at 5 degrees Centigrade.

The alkaline phosphatase was demonstrated by Gomori's technique (1939) using different substrates (Dempsey and Deane 1946); the hydrolysed substances were sodium glycerophosphate, hexose diphosphate and nucleic acid. To enable us to evaluate the zones of different enzymatic activity, the incubation time for each substrate was divided into four different periods: ten minutes, thirty minutes, three hours and twenty-four hours. The pH in all cases was 9·2. As controls, one section from each case and for each period of time was incubated in a buffer solution without the substrate. These controls later were given the same treatment as the sections incubated with the substrate. In this way we discounted the much discussed possibility that the tissues were impregnated with cobalt nitrate. Furthermore, another section was treated, without previous incubation, with cobalt nitrate

and ammonium sulphide in order to show any possible deposits of calcium phosphate existent in the tissue (Yokoyama *et al.* 1951).

When we were unable to cut the calcified material it had to be decalcified. After fixation for twenty-four to forty-eight hours normal tissues were decalcified by Lorch's method (Majno and Rouiller's 1951) and by Greep, Fischer and Morse's (1948) method; reactivation being obtained with a solution of glycine and sodium diethylbarbiturate.

So far as enzymatic loss was concerned the method of Greep *et al.* proved to us the most rapid and efficient. Pathological tissues were decalcified by the second method exclusively. As a means for controlling the enzymatic loss (inevitable during the decalcification) fragments of rat or mouse kidney (an organ rich in phosphatase), previously fixed in 80 per cent alcohol, were placed together with the tissue and followed the same process of decalcification. Furthermore, during the incubation, together with the tissue under study and the "decalcified" kidney, a section of normal kidney (not decalcified) was mounted on the same slide. By this means it was easy to deduce the approximate enzymatic loss suffered during decalcification.

The mucoproteins in the sections fixed in formalin and alcohol were stained by MacManus's technique or Hotchkiss's variation. The glycogen was studied with the same stain in sections fixed preferably in Rossman's fluid and also in alcohol, its disappearance being controlled by the action of ptyalin at 37 degrees Centigrade for two or three hours.

Metachromasia was studied with toluidine blue (0·5 per cent) according to Lison-Sylvén's technique, with 5 per cent alcohol (Wislocki and Sognnaes 1950), also at 0·5 per cent pH 1·9 (Lillie 1949) and in a very weak solution, 1 in 10,000, using a buffer of barbitone at pH 6·8 (Heller-Steinberg 1951). Only in a few cases was thionin at pH 3 and pH 5 used, according to Lillie (1948) the pH being established by acetate buffer.

The study of calcification was carried out routinely in all cases by means of silver nitrate (Kossa's method) which we found more useful than the sodium alizarin method of Dahl. It is also possible to study calcification in unincubated sections used as controls for the phosphatase technique. Reticulin fibres were stained by means of ammoniacal silver carbonate (Río Hortega's technique).

RESULTS

Normal ossification—We should describe separately the results obtained in the two fundamental types of ossification: enchondral, and membranous or direct.

Enchondral ossification—This was studied in the epiphysial cartilage of the legs of rats and mice, and in human operation specimens.

Alkaline phosphatase was not seen in the normal resting cartilage, only appearing in the proliferating cartilage area, then apparently diminishing in the hypertrophic cartilage (Fig. 1). The diminution may not have been real, because there was enlargement of cartilaginous cells by hydropic degeneration. Where bone trabeculae were forming the enzymatic activity increased visibly reaching its zenith. This activity was localised specially in the osteoblasts, being found also in the blood vessels which were very numerous in that part, and in some fibroblastic elements. The functioning bone marrow in young bones had only slight phosphatase activity.

Glycogen, which was present in moderate quantity in all the normal resting cartilage cells, increased progressively in the proliferating cartilage zone (Fig. 1). Its distribution was irregular in the hypertrophic cartilage area and disappeared abruptly when the cartilage became calcified. With the exception of a few isolated elements, we did not find intracellular glycogen in the osteoblasts of newly formed bone trabeculae. In the epiphysial centres of ossification it could be seen that, after the destruction of the hypertrophic cells full of glycogen, this substance was distributed extracellularly in the ossification zone. In the osteoblasts in this same zone we did not find glycogen (Fig. 2).

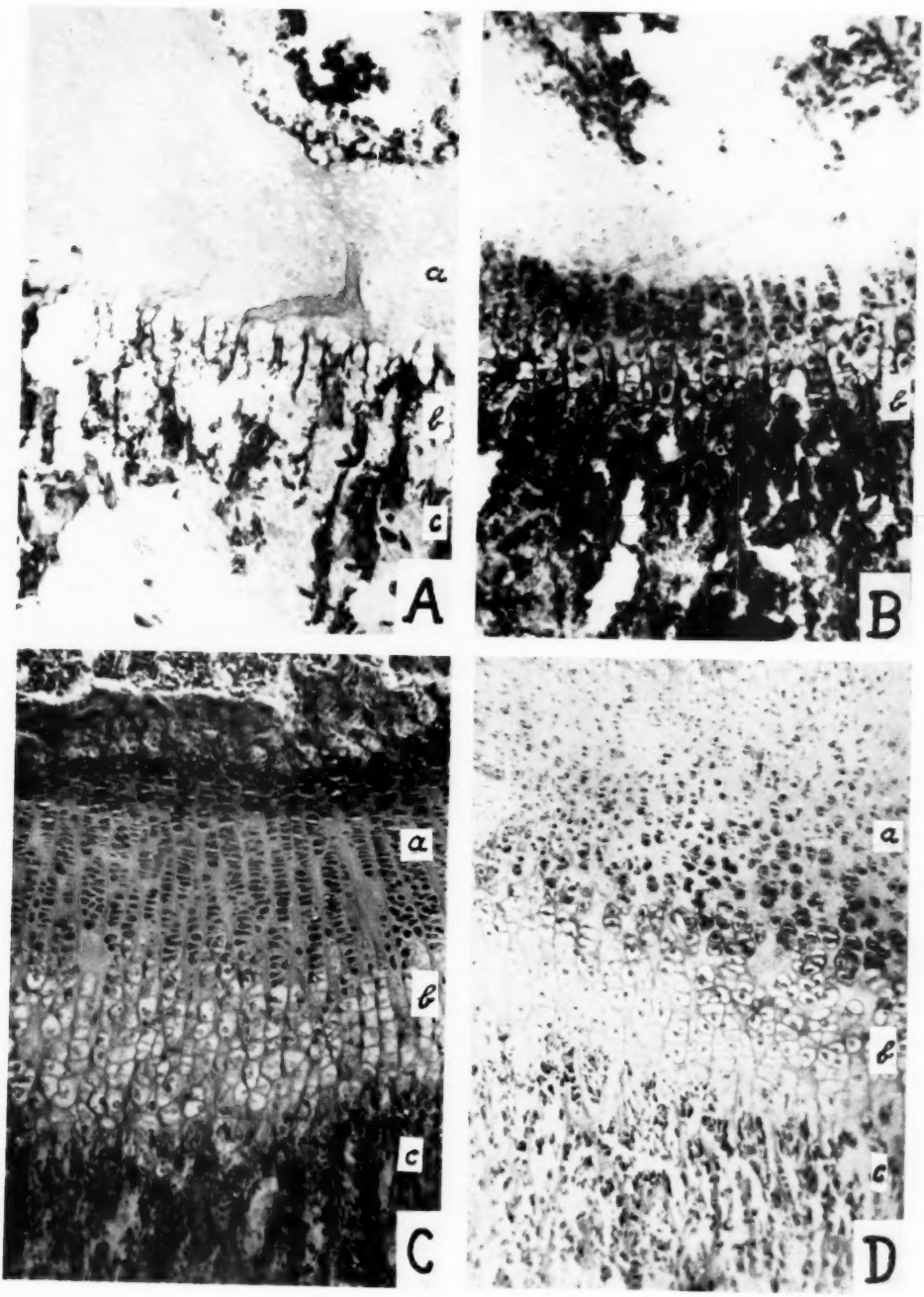

FIG. 1

Enchondral ossification in a mouse limb (two weeks old). *A*—Alkaline phosphatase. (Section incubated without substrate, by Gomori's technique.) *B*—Alkaline phosphatase. (Substrate: sodium glycerophosphate; incubation time 30 minutes, pH 9·2; Gomori's technique.) *C*—McManus's stain for mucopolysaccharides. *D*—Hale's technique (colloidal iron). *a*—Proliferating cartilage; *b*—hypertrophic and calcified cartilage; *c*—bone trabeculae in formation.

The proliferating cartilage was intensely metachromatic with all the solutions of toluidine or thionin used. We did not see an evident loss of metachromasia such as Sylvén (1947) found in the area of calcifying cartilage. The undecalcified bone did not show metachromasia even in its osteoid borders except when a normal solution (Sylvén) was used, when a weak metachromasia in osteoid tissue was obtained. The decalcified material, according to Greep, Fischer and Morse's method, suffered a gradual loss of metachromasia in relation to the duration of the decalcifying process: on the tenth day, approximately, the metachromasia finally disappeared; on the other hand Lorch's technique produced an interesting effect of inversion: while the cartilage was losing the metachromasia the bone (calcified) acquired an intense metachromasia.

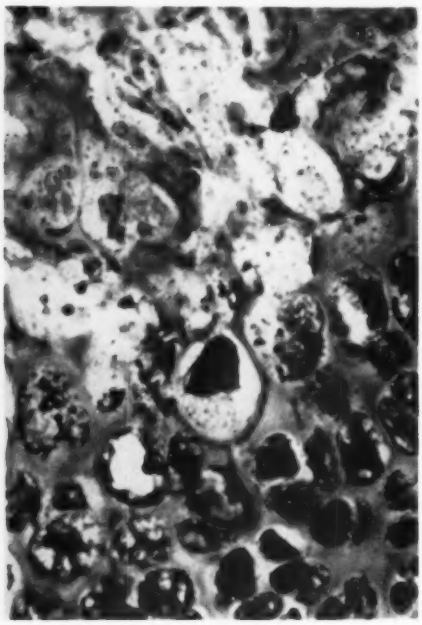

FIG. 2

Photomicrograph at higher magnification showing the enchondral ossification of the epiphysial nucleus. After the cartilage cells are destroyed the glycogen grains appear among the osteoblasts, not inside them. Mouse limb (2 weeks old) (Rossman's fixation, McManus's staining method).

Membranous ossification—This type of ossification was studied especially in the head of rats and mice. The alkaline phosphatase showed a great intensity of reaction in the areas of ossification, especially in the rows of active osteoblasts. When the osteoblasts became included in the osteoid ground substance and so became mature osteocytes, they rapidly lost the enzyme. Even in the preparations incubated for a short time, the intensity of the cobalt sulphide deposits, which indicate the localisation of the enzyme, were so large that we were often unable to distinguish clearly the cellular structure. Most of the osteoblasts contained little or no glycogen; nevertheless some newly formed trabeculae showed rows of cells containing glycogen. Granules of glycogen were also seen in mesenchymal cells close to the osteoblasts.

Pathological material—Enchondral and membranous ossification could be observed in many pathological processes, whether neoplastic or not. In these cases their distribution was irregular and at times disorderly, and of variable intensity. First we will deal with the benign and malignant tumours having these types of ossification; later with bone tumours which were neither chondrogenic nor osteogenic; and lastly with the dystrophic processes.

Tumours. *Osteochondroma*—The osteochondromas in activity presented a type of growth very like normal enchondral ossification. Alkaline phosphatase appeared in the proliferating and hypertrophic cartilage (Fig. 3); the osteoblasts of the ossifying trabeculae had a notable quantity of enzyme; there was also slight phosphatase activity in the young connective stroma richly vascularised between the newly formed trabeculae. The behaviour of the glycogen resembled that observed in the normal proliferating cartilage.

Chondroma—These tumours had no phosphatase, as in the normal resting cartilage. The metachromatic reactions were like those of the articular and epiphysial cartilage. There was a moderate and variable quantity of glycogen in all the cartilage cells; the regressive processes so common in these tumours were accompanied by a loss of glycogen and, often, of metachromasia.

Chondrosarcoma—The true cartilaginous neoplastic lobules, as in the case of chondromas, had no phosphatase activity. Glycogen was present in all the living cells, but disappeared in the necrotic. In the frequent neoplastic areas that were undergoing calcification an evident phosphatase activity appeared, localised in the cartilaginous cells (Fig. 5), accompanied in some cases by an increase of glycogen, which as a rule diminished and even disappeared in the completely calcified areas.

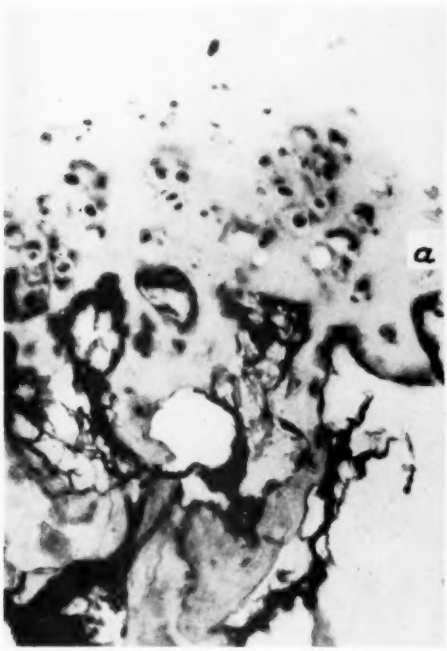

FIG. 3

FIG. 4

Figure 3—Osteochondroma. *a*—Great enzymic activity in proliferating, hypertrophic and calcified cartilage, also in formation of bone trabeculae (enchondral ossification). Alkaline phosphatase. (Substrate: sodium glycerophosphate, pH 9·2, incubated for 3 hours, decalcified by Greep, Fischer and Morse's method.)
Figure 4—Chondroma of the scapula in active proliferation. The cartilage cells in calcification show a great enzymic activity. (Substrate: sodium glycerophosphate, pH 9·2; incubation time 3 hours; no decalcification.)

When centres of enchondral intra-tumoral or reactionary ossification in the interlobular stroma appeared in the chondrosarcomas, phosphatase reached very high levels, being specially abundant in the osteoblastic cells. These cells, with some exceptions, also contained abundant glycogen. The cartilage in the chondrosarcomas was intensely metachromatic but the intensity varied greatly in different parts. We might say that the metachromatic reaction was histochemically atypical. The process of calcification and enchondral and reactionary ossification in the chondromas was identical with that in chondrosarcoma.

Osteoid osteoma—We include this in the group of tumours although its nature is not clearly defined. There exists an osteogenic central nucleus formed by a stroma having abundant blood vessels and young mesenchymal elements showing fibrous and osteoblastic differentiation in which there is an intense neoformation of osteoid and calcified (reticular) bone trabeculae. In this nucleus an intense phosphatase activity was observed in the connective tissue which increased in the osteoblasts, while areas of osteoclastic resorption showed variable but weaker enzyme activity.

Osteogenic sarcoma—The case studied belonged to a sclerosing variety; all the tumour cells had an intense enzymatic activity (Fig. 6) which became clearly visible after ten minutes' incubation. Many parts were so charged with cobalt sulphide that it was difficult to observe details of the cells. In most cases, coincidentally with the phosphatase, the tumour cells presented numerous granules of glycogen. Giant cells (of the osteoclastic type with numerous small nuclei) generally showed only slight enzymatic activity and contained little glycogen.

Giant-cell tumours of bone—The typical benign cases of this tumour showed intense enzymatic activity almost confined to the vessels (Fig. 7). The giant cells and the fibroblastic and reticulo-histiocytic stroma reacted weakly only after twenty-four hours. Glycogen was not observed in these tumours.

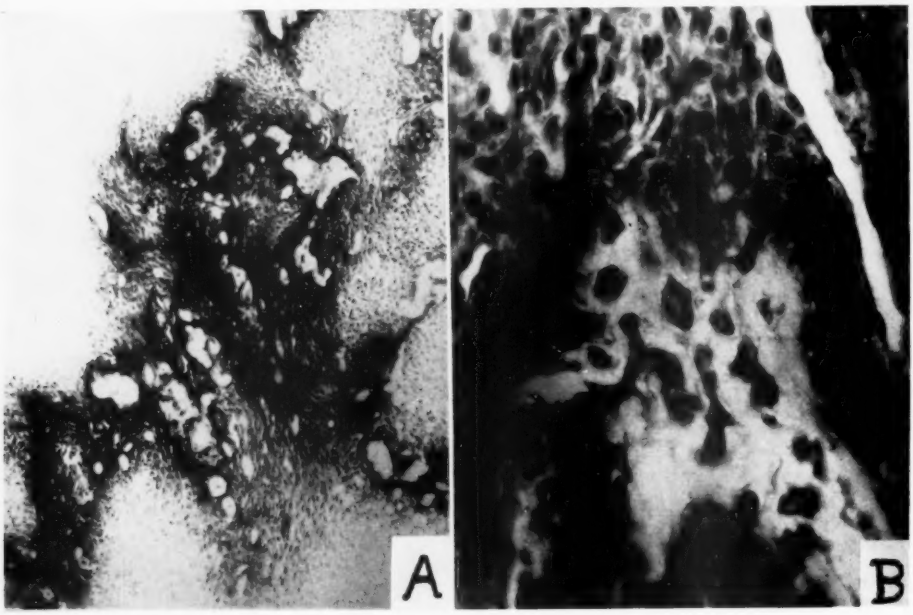

FIG. 5

Primary chondrosarcoma of femur (high grade of malignancy). Some tumour areas which show intense proliferation of indifferentiated elements demonstrate in some places a tendency to form osteoid tissue. *A*—Low magnification. Great activity is seen in the connective tissue, especially around bone trabeculae. *B*—One of the trabeculae at higher magnification. (Substrate: hexose-diphosphate, pH 9·2, incubated for 10 minutes; no decalcification.) The young bone cells included in the trabeculae still maintain enzymic activity.

One of the cases studied showed signs of sarcomatous osteogenic transformation, with some zones of intra-tumoral osteoid tissue formation, and in it we observed intense phosphatase activity in the osteoblasts which surrounded the new bone trabeculae (Fig. 8). We would like to point out that, with the ordinary histological techniques, it is difficult to disclose these intra-tumoral osteogenic areas. They are an important indication of incipient sarcomatous transformation in a giant-cell tumour.

Giant-cell tumour of synovial membrane—The histochemical behaviour was identical with that of the tumours in the previous group. In these neoplasms fascicles of collagen—usually hyalinised and very difficult to distinguish from osteoid when using the usual histological techniques—were often present. Nevertheless, the absence of phosphatase allowed us to discount the presence of bone formation. None of the giant-cell tumours reacted metachromatically.

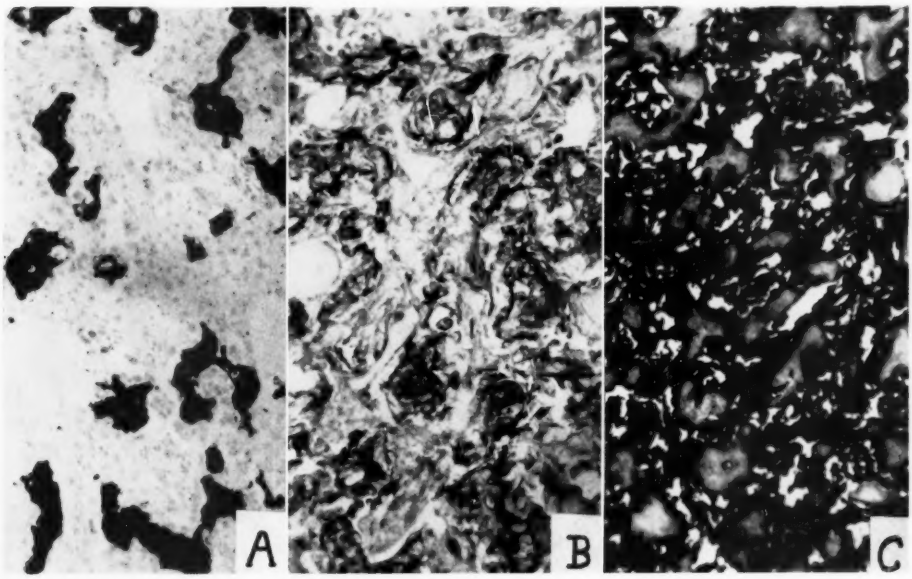

FIG. 6

Osteogenic sarcoma of lower part of tibia (sclerosing type). *A*—Calcium demonstration with silver nitrate (von Kossa's method). *B*—Alkaline phosphatase in an undecalcified section, incubated for 30 minutes in sodium glycerophosphate, pH 9·2. *C*—Same case decalcified by Greep, Fischer and Morse's method. The trabeculae are clearly visible owing to the loss of calcium and are surrounded by tumour cells with great activity (incubated 24 hours, substrate; sodium glycerophosphate, pH 9·2).

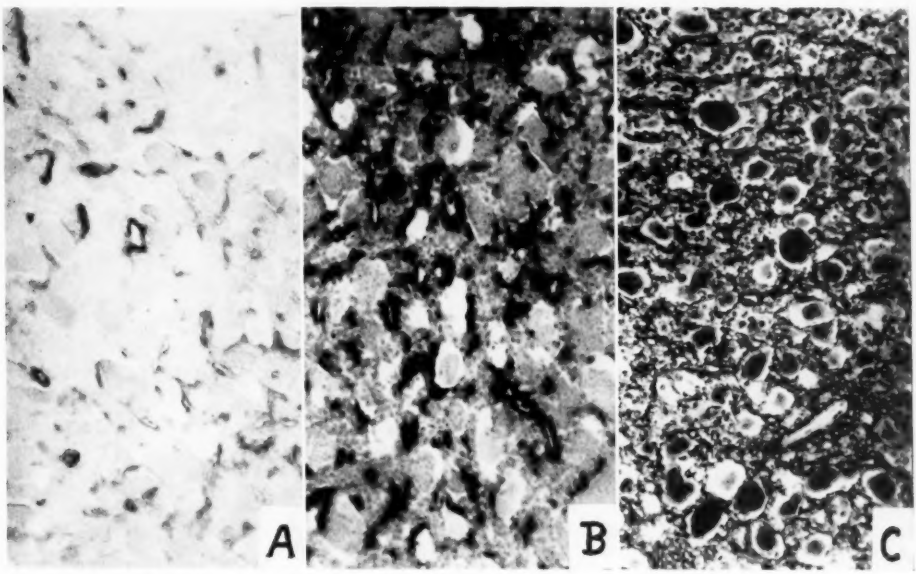

FIG. 7

Benign giant-cell tumour of bone. *A*—Alkaline phosphatase after 10 minutes of incubation. It is observed that the enzyme is localised only in the blood vessels. *B*—Another section after 24 hours' incubation. (Substrate in Sections *A* and *B* was sodium glycerophosphate, pH 9·2).
C—Río Hortega's stain for reticulin fibres. A dense net of reticulin fibres surrounds the tumour cells.

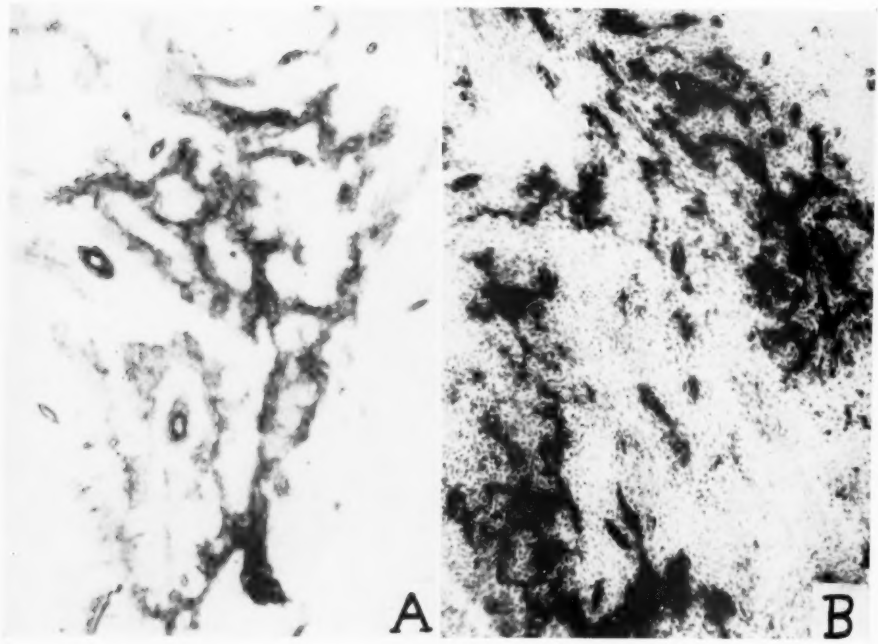

FIG. 8

Giant-cell tumour with early sarcomatous transformation. *A*—After 10 minutes' incubation a high phosphatase activity in the osteogenic zone is clearly demonstrable. (Substrate: hexose diphosphate, pH 9·2.) *B*—Another section incubated for 24 hours; the stroma cells also show activity. (Substrate: sodium glycerophosphate, pH 9·2.)

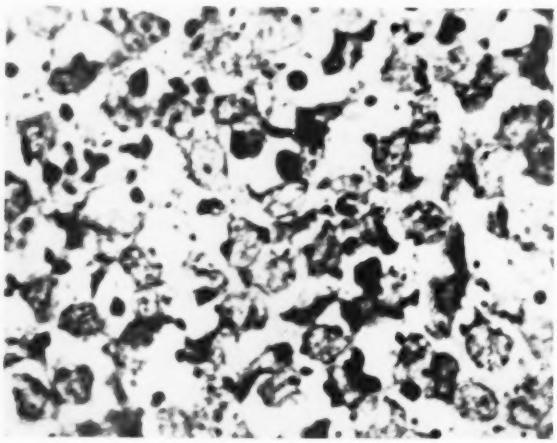

FIG. 9

Ewing's sarcoma. Numerous grains of glycogen are seen in the cytoplasm of the tumour cells. (McManus's staining.)

Ewing's sarcoma—With the exception of the vessels, the tumour tissue did not show any enzymatic reaction. When studying the presence of glycogen in the tumour cells in this case, in a series of tumours of the same type, and in primitive reticulum-cell sarcomas of bone, we noticed the presence of glycogen granules in Ewing's sarcoma and their absence in the reticulum-cell sarcomas (Schajowicz 1953) (Fig. 9).

Myeloma—The cells of this tumour presented from a weak to a moderate phosphatase activity; on the other hand the vessels reacted intensely, as frequently happened in other pathological processes. No glycogen was found in the tumour cells.

Liposarcoma—Here we are surprised by the enormous phosphatase activity (Fig. 10) which was clearly visible after ten minutes' incubation. The tumour cells did not contain glycogen.

Metastatic carcinoma—In the four cases studied (none prostatic), alkaline phosphatase appeared only in the zones of reactive bone formation.

FIG. 10

Liposarcoma of thigh. All the cellular elements have a great quantity of enzyme. (Incubated three hours using hexose diphosphate substrate, pH 9·2.)

Dystrophic disorders. *Paget's disease*—This condition, characterised by an active and disordered process of bone transformation, especially lends itself to the study of osteogenesis. The direct relation of the active osteoblasts to the evident increase of alkaline phosphatase was clearly seen (Fig. 11). The giant cells of the osteoclastic type, even in the Howship's lacunae (Fig. 11) reacted weakly, contrary to observations made by Majno and Rouiller (1951). Furthermore, the connective stroma, full of vessels and cells potentially osteogenic, showed marked phosphatase activity.

Polyostotic fibrous dysplasia—In this condition, which is characterised by bony metaplasia within a mesenchyme connective tissue, we observed an intense phosphatase activity in the stroma and an even more marked reaction on the surface of the new trabeculae, covered by rows of osteoblasts. The internal layer of the periosteum and endosteum showed great enzymic activity, as in Paget's disease. Only in a few places did osteoblasts contain glycogen, but as the material had been decalcified we do not consider it possible to draw any definite conclusion about this substance.

Bone cyst—In a case of an active bone cyst in a young child we observed intense alkaline phosphatase activity in the cyst wall, as well as in the periosteum (Fig. 12).

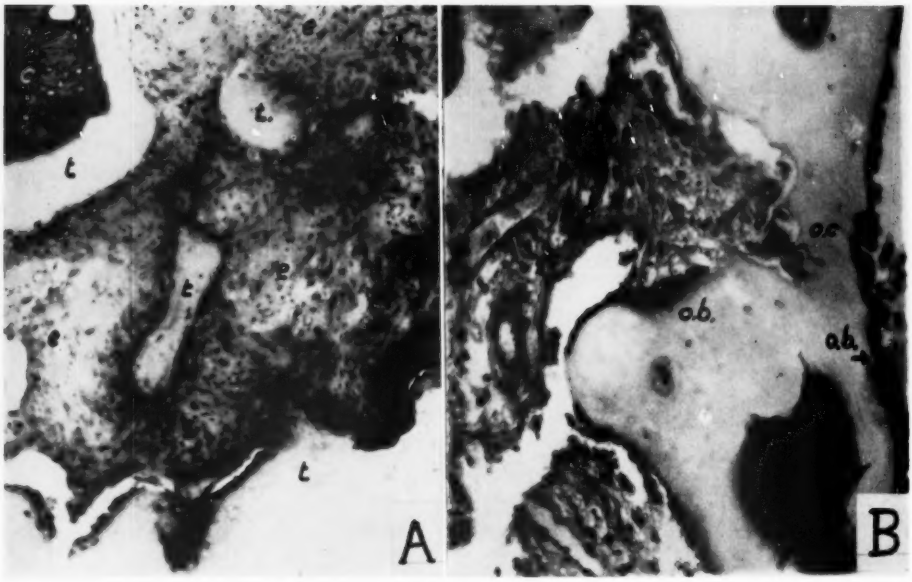

FIG. 11

Case of typical Paget's disease of bone. *A*—A moderate phosphatase activity of the stroma (*e*), greatest on the surface of the trabeculae. *B*—Higher magnification. The alteration of apposition zones containing functional osteoblasts (*ob*) with zones of resorption containing osteoclast (*oc*) is clearly seen. While the osteoblasts show a great enzymic activity (*ob*) the osteoclast (*oc*) has a low enzyme content. (Substrate: sodium glycerophosphate, incubated 24 hours, pH 9·2; material decalcified by Greep, Fischer and Morse's method.)

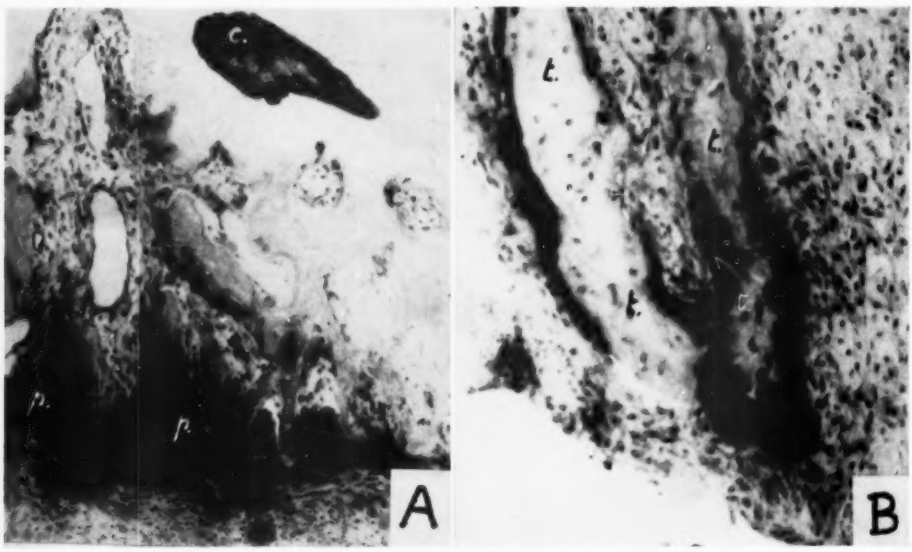

FIG. 12

A—An intense activity of phosphatase in the internal layer of periosteum (*p*) that covers a bone cyst of a child; a cortical zone not completely decalcified (*c*). *B*—Newly formed fone trabecula (*t*) in the wall of a bone cyst. (Substrate: sodium glycerophosphate, incubation time 24 hours, pH 9·2); specimen decalcified by Greep, Fischer and Morse's method.

Eosinophilic granuloma—As in the giant-cell tumours, we found phosphatase in great quantity in the walls of the blood vessels, but it was almost absent from the remaining tissue, which is rich in reticulin fibres. Nevertheless in some areas of collagen fibre formation the enzyme increased moderately. We did not find glycogen in the cellular elements of this lesion.

Reactive bone formation—This process is identical with membranous or direct bone formation; we find it in every type of tumour in the septum that separates the tumour tissue and especially in its periphery. The same type of bone formation can be seen in different dystrophic and inflammatory processes and it constitutes a typical defensive mechanism of the bone. The distribution and intensity of the enzymic activity is identical with that of normal membranous ossification.

DISCUSSION

For assessment of the histochemical findings in the process of ossification we should bear in mind the existence of the two fundamental types of ossification: the enchondral and the membranous. We should remember that in enchondral ossification there is a previous stage which takes place in the cartilage and which is characterised by its proliferation, hypertrophy and subsequent calcification. Only then, and after its destruction, are the actual bone trabeculae formed. On the other hand, the cartilage has no part in the mechanism of membranous or direct ossification, where the osteoblastic elements originate first, then the fundamental (osteoid) substance, and later the true calcified bone.

Most biochemical studies of the formation of bone have stopped at the calcification of hypertrophic cartilage. In reality, calcification of the cartilage is a previous stage in enchondral ossification and has no part in direct ossification; on the other hand, the cartilage can become calcified without subsequent ossification.

Since Robison in 1923 showed the presence of abundant alkaline phosphatase in the ossification zones, his first hypothesis has been subjected to some modifications. At that time he suggested that phosphatase would hydrolise organic substances that had a radical phosphate in their molecules; on being separated, its concentration would increase and, as calcium also would be present, the relation phosphate-calcium could easily reach its limit of solubility and thereby calcium phosphate would be precipitated. Nevertheless it proved difficult to explain the great abundance of enzyme in parts that did not become calcified, such as the duodenum or the kidneys. Robison himself then suggested that, besides the phosphatase there would have to be some other process (secondary mechanism) which, together with the first, would bring about the precipitation of calcium salts (Robison and Rosenheim 1934).

For some years Robison's theory was admitted, although with certain reservations, the phosphatase being considered a fundamental factor in the process of calcification. The discovery of another enzyme, phosphorylase (Gutman *et al.* 1941, 1942, 1950), as also the presence of glycogen (Harris 1932, Horowitz 1942, Follis and Berthrang 1949) in great quantities in the cartilage about to become calcified, and also its final disappearance when once the calcification is completed, attracted the attention of these authors. They tried to explain calcification by relating it to the cycle of glycogenolytic processes like those produced in muscles. Recently Albaum *et al.* (1952), by chromatographic analysis in the calcifying cartilage, have confirmed the presence of the same intermediary substances and enzymes as are produced in the anaerobic glycogenolysis of muscle. Gutman (1951) does not deny that phosphatase plays a part in ossification, but he does not believe that this part can be the separation of the ion phosphate for its ultimate precipitation; on the other hand, perhaps it might be to produce chemical changes which prepare the cartilage for its calcification (calcifyability); this is the so-called " local factor " (McLean 1950); Sobel (1950) considered that this factor seems to obey only " physical-chemical concepts in some respects."

The decrease and disappearance of glycogen in the zone of calcifying cartilage " can be simply a phase of autolysis in dying cells " (Ham 1953).

On the other hand Sylvén (1947) observed an evident loss of metachromasia in the

calcified cartilage zone, which would coincide with an increase of pH, thereby creating a favourable environment for the action of the abundant phosphatase in this same zone.

Rubin and Howard (1950), on the contrary, found an increase of metachromasia if the precaution was taken to " prepare the ground " first with weak acids (such as lactic) which would split off calcium from the mucopolysaccharides. According to these workers the chondroitin-sulphuric acid might act in the manner of an ionic interchange resin.

Having analysed briefly these investigations into the biochemistry of calcification and the theories deduced from them, we will now compare them with the results we have obtained in the study of normal and pathological ossification.

According to what we have found in normal material, it is evident that all the areas that were about to be calcified, or that were in process of ossification, had a marked quantity of alkaline phosphatase. On the other hand, the glycogen, which appeared in great quantities in other areas of cartilage, was not seen with the same frequency and abundance in the true ossification areas. In other words, every time the cartilage became calcified there had been a previous increase in the glycogen content of the cartilage cells. This disappeared abruptly at the very moment of calcification; but, together with the increase of glycogen, phosphatase appeared, which did not exist before in the normal cartilage, and which increased its intensity in the calcified area. On the other hand, the areas that were actually becoming ossified did not present glycogen with any regularity, having always an enormous quantity of phosphatase.

The osteoblasts in enchondral ossification seldom contained glycogen; this was seen more often in membranous ossification.

Bevelander and Johnson (1950) who studied membranous ossification admitted that the osteoblasts are rich in glycogen, but affirmed that this is lost at some time or other in the differentiation of the cell. We do not understand very well the interpretation offered by these authors for in our preparations the areas of osteoblasts with glycogen in regions of membranous ossification were very few, and in enchondral ossification it was practically invisible. From these results we believe that the intervention of phosphatase in the formation of bone (osteogenesis) can be affirmed; but, to us, the importance of glycogen, which only appears in some places of ossification besides the *calcification* of cartilage, is not so clear.

When speaking of osteogenesis we do not mean to imply only calcification. The process of bone formation is divided classically into two stages: first, the formation of a protein ground substance which is clearly distinguishable in the osteoid area of forming bone, and then its calcification to form true bone.

The intervention of alkaline phosphatase in the formation of the protein matrix of bone appears to be well accepted by most authors (Bradfield 1949, McLean 1950, Follis 1952) since Fell *et al.* 1943, Danielli *et al.* 1945 showed that phosphatase was present in quite high concentration in the young connective tissue that was formed in the healing process of experimental wounds in rats and guinea pigs. In scorbutic guinea pigs healing was interfered with and the phosphatase was absent. If ascorbic acid was supplied to these animals, phosphatase reappeared and normal connective tissue was formed.

Various other authors could confirm these results (Cabrini and Carranza 1951, Gould and Gold 1951, Follis 1952, Ring 1952, Zorzolli and Nadel 1953). Furthermore, in the ossification zones of rachitic rats, where calcification is defective (Morse and Greep 1951) but osteoid (bone matrix) formation continues, phosphatase is present in almost normal quantity.

The correlation of phosphatase activity with the elaboration of the fibrous protein matrix seems to be confirmed by the presence of abundant ribose nucleic acid in the cytoplasm of active bone-forming osteoblasts, which we could demonstrate constantly in these elements, confirming similar findings of Follis (1952) and Ham (1953). That ribose nucleic acid is associated with protein synthesis seems to be well accepted (Caspersson 1947).

The analysis of the results we obtained in the pathological cases leads us to confirm our observations in the normal cases. In tumour processes, every time the formation of bone

(or bone ground substance) began, phosphatase increased and reached an extremely high level. That is how it appeared in osteochondromas, in ossification and calcification zones of chondromas and chondrosarcomas, in osteogenic sarcomas and in the processes of reactionary new formation of bone.

Glycogen, on the contrary, in the same processes was inconstant and irregularly distributed: very abundant in osteogenic sarcoma, less and even absent in the other processes. Nevertheless we cannot come to any definite conclusions about the behaviour of glycogen because most of the pathological material had to undergo decalcification, which greatly alters the disposition of the glycogen. We are now endeavouring to assess the influence of the different types of decalcifying agents on the histochemical detection of glycogen.

Where cartilage grew rapidly, as in the chondrosarcomas, no increase of phosphatase was seen; therefore we discount its influence in the formation of cartilage ground substance. When the cartilage of the osteochondromas, chondromas and chondrosarcomas became calcified, at the same time as the glycogen increased in parts surrounding the area, we noticed that phosphatase appeared with notable intensity. Without being able at the moment to explain how it acts, we believe it is here that phosphatase intervenes in the process of calcification of the cartilage ground substance. The same histochemical picture is repeated in tumour cartilage as in calcification of the epiphysial cartilage: simultaneous increase of glycogen and phosphatase, decrease or disappearance of glycogen in the completely calcified cartilage.

It was interesting to see how, in Paget's disease, on the surface of the trabeculae, zones of great phosphatase activity alternated with others that had no enzyme at all; these corresponded respectively to rows of functioning osteoblasts and areas without any. There was an evident relationship between bone apposition and phosphatase activity. The relation between osteoclastic resorption and enzymatic activity is not so clear: most of the osteoclasts, even those in Howship's lacunae, showed little enzyme, which disagrees with Majno and Rouiller's observations (1951).

In Paget's disease, as well as in fibrous dysplasia, considerable phosphatase activity was observed in the young connective stroma that separated the bone trabeculae, in accordance with the osteogenic power that we believe this tissue has.

We would like to stress that, in our study of giant-cell tumours, we did not observe any important phosphatase activity in the stroma or in the giant cells, and saw it only in small blood vessels. In the one case presenting signs of sarcomatous transformation with formation of osteoid within the tumour we found an intense phosphatase activity in those areas of osteogenesis. Moreover, phosphatase technique allowed the areas of hyaline change in the giant-cell tumours of the synovial membrane, which showed no enzymic activity, to be distinguished distinctly from osteoid, which reacted intensely. Although these tumours contain a great amount of reticulin fibres which surrounded almost all the cells, the absence of phosphatase in the stroma allows us to discount its influence on the development of reticulin fibres in the tumours.

We ascribe the large amount of phosphatase in our case of liposarcoma to the importance conferred on the phosphate radical in the metabolism of lipids.

SUMMARY

1. Histochemical studies have been made of the distribution of alkaline phosphatase, glycogen and acid mucopolysaccharides in normal growing bones (mice, rats and men) and also in forty cases of pathological bone processes (neoplastic and dystrophic).

2. The study of normal material confirmed that alkaline phosphatase is plentiful in calcification of cartilage and even more plentiful in bone formation (whether enchondral or direct).

3. It was observed that glycogen increased in the cartilage areas about to be calcified, and that it disappeared in those calcified. It seemed that osteoblasts did not always contain glycogen.

4. In the pathological material (tumours and dystrophic processes) there was great phosphatase activity in the osteogenic areas and also in the cartilage about to be calcified. Whereas glycogen was plentiful in some cases of neoplastic or reactive osteogenesis, it was absent from others.

5. In every area of normal or pathological ossification, the presence of phosphatase seems to be a rule; glycogen is often but not always present.

6. It appears that alkaline phosphatase plays an important role in the formation of the protein matrix of bone, but is not associated with the elaboration of the mucoprotein cartilage matrix.

We believe it is premature to draw any definite conclusion on the behaviour and role of the metachromatic substances in the processes of calcification and ossification.

The histochemical study of alkaline phosphatase has shown that this is a valuable method in the detection of reactionary or pathological osteogenic processes which in some cases are difficult to demonstrate with the usual histological methods.

We are grateful to Professors José Valls and Carlos E. Ottolenghi for most of the pathological material, and to Dr José M. Lascano Gonzalez for granting the use of his laboratory. We also acknowledge the technicians Mrs Adela de Schajowicz and Miss Noemi Rosner for their efficient collaboration.

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HISTORICAL SURGICAL INSTRUMENTS IN THE MUSEUM OF THE ROYAL COLLEGE OF SURGEONS OF ENGLAND (6)

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One of the Sections which was totally destroyed, except for four exhibits, was Section " I "—Instruments for Operations on the Extremities. This Section contained several cases of amputating instruments of the eighteenth and early nineteenth centuries, various types of amputation knives, saws, artery forceps and tourniquets.

Of the four exhibits saved only two are worth mention. One, a case of amputation instruments probably used at the Battle of Waterloo, has already been referred to in the first of these articles. The second exhibit is the circular retractor seen in Figure 52. It consists of two irregular metal plates hinged together with a pin, on which works a flat slide; two handles, one of which is missing, were attached to the extremities of the plates. No figure or reference to this retractor has been seen in Brambilla's (1782), Savigny's (1798), Seerig's (1838) and other atlases consulted. It has been in the Museum for over eighty years, the donor's name is not known, and no history is attached to the entry in the manuscript catalogue of 1878, which simply states that it is " a circular retractor."

FIG. 52
Circular retractor of unknown date.

The phlebotomy bow seen in Figure 53 was presented by Mr W. H. Bailey and entered in the catalogue as " A bleeding instrument, like a cross-bow used by the Maltese." Unfortunately no notes of this exhibit, if any existed, have been preserved, nor has the date of presentation been recorded. The fleam, with a straight cutting edge, is mounted on a wooden stem which runs in the interior of the stock; the stock is cut like an open mouth at its free end. To operate the instrument, the bowstring is drawn down and the trigger inserted, thus holding the fleam inside the stock. On withdrawing the trigger the stem flies forward and the fleam punctures the vessel against which it is applied.

What is perhaps the oldest exhibit in the Instrument Collection is the bleeding bowl seen in Figure 53. It is made of pewter and has a diameter of four and a half inches and a depth of an inch and a half. Stamped on the bottom is a dove bearing a branch in its mouth, the letters " R. B." and the date 1671.

Two examples of the eighteenth century spring fleam or German bleeding lancet are also shown in Figure 53. The first consists of a plain oblong brass box containing the mechanism for operating the fleam. This instrument is figured in Heister's *System of Surgery* (1753), and one of a somewhat similar design is figured in Seerig's *Armamentarium* of 1838, where it is

described as " the old bleeding fleam of an unknown inventor." Its mechanism is similar to that in the specimen shown above it. This second example is Heuermann's spring fleam or bleeding lancet. It is a silver box ornamented with leaf patterns, and contains a triangular-

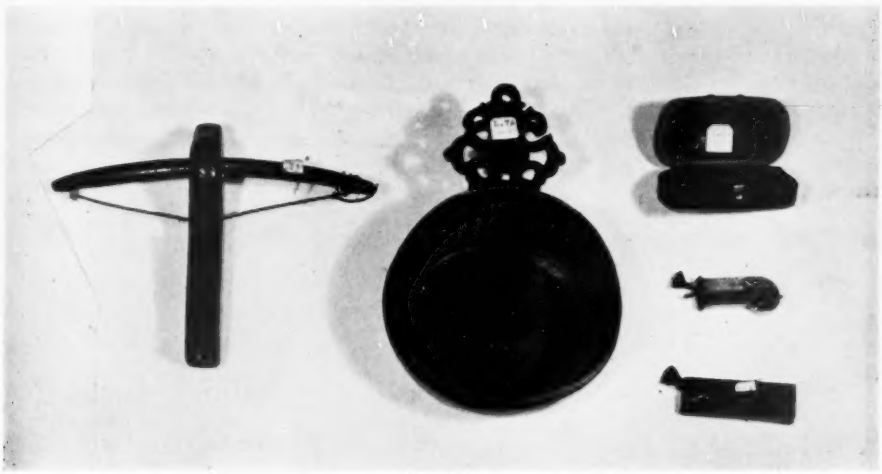

FIG. 53

Left—Phlebotomy bow. *Centre*—Pewter bleeding bowl dated 1671. *Bottom right*—Spring fleam or German bleeding lancet (eighteenth century). *Above*—Heuermann's spring fleam or bleeding lancet with its case (eighteenth century).

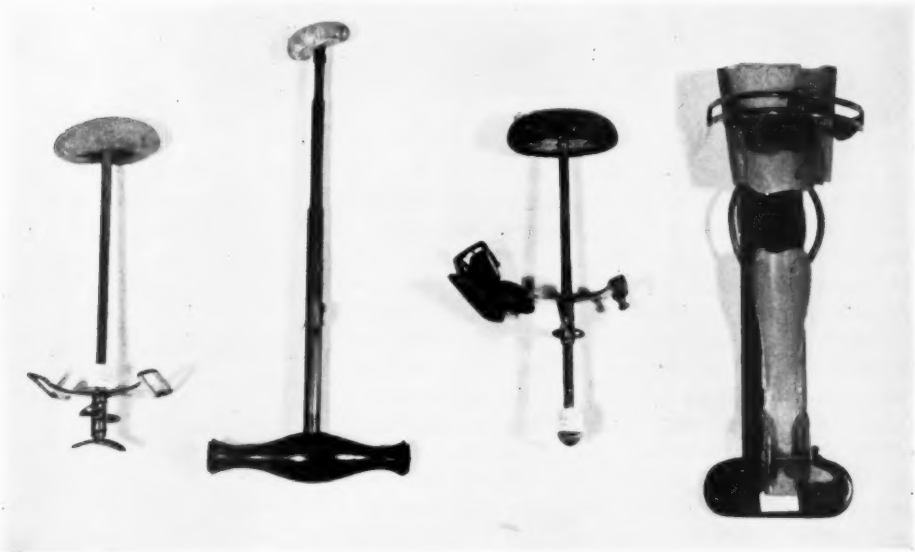

FIG. 54

Left to right—Luke's artery compressor for aneurysm; Cole's pad for elastic pressure in aneurysm; Cole's artery compressor; and Cole's instrument for compressing the femoral artery.

bladed knife with trigger and spring. A lever, mounted on the outside, controls the trigger. The fleam, with two spare blades, is preserved in a case covered with green shagreen and lined with red plush. It is figured in Brambilla's *Instrumentarium Chirurgicum Militare* (1782) and in Seerig's *Armamentarium* (1838).

Among the many ingenious instruments invented by James Luke (1799–1881) is an example of his artery compressor for the cure of aneurysm (Fig. 54) presented in 1862. The apparatus was buckled round the limb, the pad being applied over the vessel. A binding screw allows the pad to be pressed on or relaxed as desired. In 1871 George C. Coles (1843–1880) presented three instruments which he designed, the first being a pad for elastic pressure in the treatment of aneurysm (Fig. 54). This pad is described by the inventor in the *Medical Press and Circular* of 1867 under the title "Description of an Instrument for the Treatment of Aneurysms by Elastic Pressure." The contrivance, writes the inventor, "consists of a trephine handle to the centre of which is fixed a stem, composed of three cylindrical pieces which fit into each other, the upper two of which each contain a spring, the lower one is

FIG. 55
Transfusion apparatus, early nineteenth century.

solid and has attached to its extremity a small screw; at an obtuse angle to this screw several small pads of different sizes can be fixed . . . By placing this pad on the vessel to be compressed and holding the handle in the palm of the hand, any amount of pressure can be obtained . . . and by this means a steady uniform, elastic pressure may be obtained for any possible length of time." The second instrument is an artery compressor (also shown in Figure 54) which is a modification of Luke's model. Coles's third instrument is a model of the apparatus for compressing the femoral artery in the treatment of aneurysm or elephantiasis (Fig. 54). It was described in the *British Medical Journal* of 1871. This model was exhibited at the meeting of the British Medical Association at Leeds in 1869 and also at the Medical Society of London in 1870.

Early nineteenth century transfusion instruments, packed in a mahogany box, are seen in Figure 55. A brass plate on the lid of the box bears the following inscription: "Medical School, 58 Aldersgate Street. Mr Waller's obstetrical prize for the session of 1829–30 adjudged after a careful examination to Mr W. J. F. Wilson." The box contains a brass syringe, two mounts each with transfusion needle, a brass key and a metal funnel. The instruments were made by "Ferguson, St Bartholomew's Hospital, London," and were presented to the Museum in 1891 by Sir Erasmus Wilson, Bart.

The collection has many examples of cupping sets in cases, scarificators of silver and brass with a varying number of blades, and cupping glasses of different shapes and sizes. A leather-covered case contains two silver scarificators and a silver spirit lamp with the hall-mark date-letter for 1793 (Fig. 56). The case originally belonged to Dr J. Atkinson, a Brighton

surgeon, whose initials are inscribed on a silver plate on the lid of the case, on the spirit lamp and on each scarificator. The larger scarificator has ten blades and the smaller twelve; the spirit lamp is shaped like a teapot. A ten-bladed silver scarificator marked with the date-letter for 1828 is also seen in Figure 56. It formerly belonged to Dr Page Nicol Scott, of Norwich, and was purchased by the donor in Malvern in 1919. A hand scarificator (Fig. 56) consists of an ornamented bronze stem inserted in a chequered ivory handle. The other end of the stem divides into two branches, between which is a rod bearing six blades. It was presented in 1875, the donor stating that it was used many years before by a predecessor.

FIG. 56
Top row—Two silver scarificators and spirit lamp, 1793. *Below*—Ten-bladed silver scarificator dated 1828, and a hand scarificator of the early nineteenth century.

A case containing a set of artificial leeches, made by " W. Kidston & Co., Manufacturers, 18 Bishopsgate St., London. Red. Feb. 11th, 1850," is seen in Figure 57. The case contains two plated white metal tubes, or scarificators, joined at the base at an angle of 40 degrees. The shorter tube contains three fine lancets, and the larger a piston to form a syringe; there are also three glass syringes to suck up blood. J. J. Tweed (1819–1902), who writes as if artificial leeches were his own invention, was the author of an article in the *Medical Times* of 1850 entitled " A Description of the Apparatus for employing the Mechanical Leeches."

The Laennec stethoscope seen in Figure 58 is similar to that illustrated in the Plate in *A Manual of Percussion and Auscultation* composed from the French of Meriédec Laennec (a cousin of the inventor) by James Birch Sharpe in 1832, except that the obturator end of the auricular segment is cut sharp instead of rounded. The description states: " The drawing in this plate gives the simple and original form of the stethoscope as invented by the great Laennec . . . " René Théophile Laennec (1781–1826), the inventor of the stethoscope in 1819 and author of *De l'auscultation médiate*, first made use of a cylinder of paper, formed of three quires kept together by paste. He then experimented in wood, metal, glass, and beaten skin, and finally decided in favour of a cylinder of wood. There were originally five examples of Laennec stethoscopes in the Collection, four of them being destroyed by enemy action. Of the four lost, one was used by the inventor himself, and another was once the property of a pupil of the inventor.

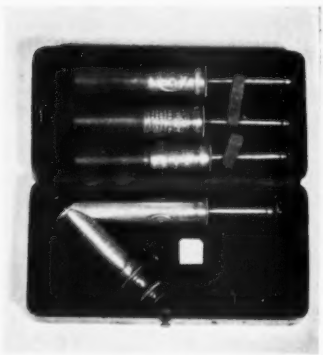

FIG. 57
Case of "artificial leeches," 1850.

The Weis-Czermak auto-laryngoscope seen in Figure 59 " belonged to Professor Willis, of Cambridge, and was used by him in his experiments on the voice." The Rev. Robert Willis, F.R.S., (1800–1875) was the son of Dr R. D. Willis, physician to George III. He was an authority on animal mechanism and contributed to the *Transactions of the Cambridge Philosophical Society* a memoir on " Vowel Sounds " (1828) and another on the " Mechanism of the Larynx " (1828–29).

Figure 60 shows " a pair of Perkins's tractors formerly in use at Bath, and much used as curative of many diseases " presented by Dr Charles Coates of Bath in 1878. These tractors, one of which is made of zinc and the other of copper, were in great demand over a century ago. Perkins, son of the inventor, wrote a work published in London in 1798 entitled *The influence of Metallic Tractors on the Human Body in removing various inflammatory diseases, such as Rheumatism, Pleurisy, some Gouty Affections, etc., etc., lately discovered by Dr Perkins of North America and demonstrated in a series of experiments and observations, by Professors Meigs, Woodward, Rogers, etc., etc., by which the importance of the discovery is fully ascertained, and a new field of enquiry opened in the modern science of glavanism, or animal electricity.* The

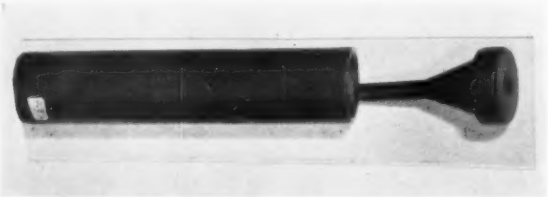

FIG. 58
Laennec's stethoscope, original form.

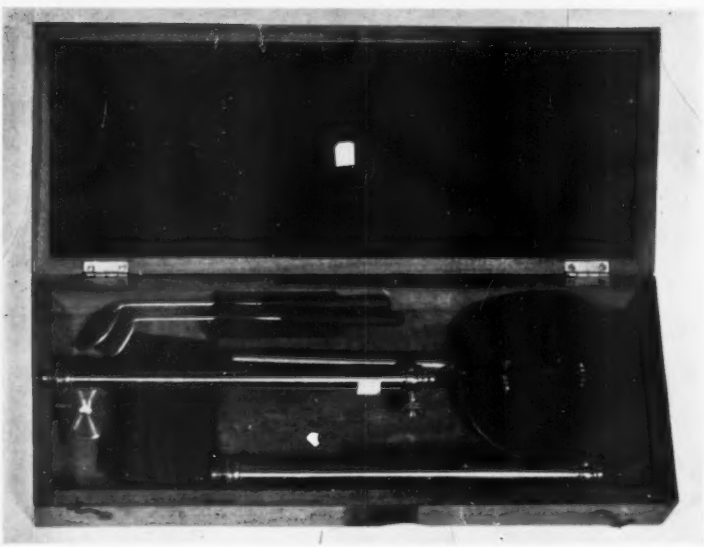

FIG. 59
Weiss-Czernak's auto-laryngoscope used by Professor Willis in his experiments on the voice.

College library possesses a copy of this publication. The tractors were invented by Elisha Perkins of Connecticut and were used in perfect good faith by the inventor. The points of the tractors were drawn over the affected parts for about twenty minutes. Perkins took out a patent for his tractors, and was expelled from the Medical Society of the State of Connecticut in 1800. He came to Europe, and when in London is said to have occupied the house in Leicester Square previously belonging to John Hunter. In Bath, the tractors became popular, and the pair illustrated were employed by a physician in that city, where however two medical practitioners had some false ones made and effected faith-cures just as well as by the genuine

tractors. Perkins retained faith in his invention and when yellow fever was raging in New York he went there and endeavoured to cure the disease with his tractors, but fell a victim to the fever.

An artificial nose made of silver and fixed to the bridge of a silver spectacle frame is seen in Figure 61. The frame is so made that it can be adjusted over the top of the head and to the nape by means of slots and button-shaped pegs. On the inner side of each of the side pieces, close to the hinges, are engraved the initials "M. H." of the maker and a hall-mark,

FIG. 60
Perkins's metallic tractors.

FIG. 61
Artificial nose mounted on a spectacle frame.

the lion rampant only being now distinguishable. A note in the catalogue states: "An artificial nose from the collection of the late James Merryweather. The patient presented herself wearing the said apparatus. She was also deficient in teeth, as well as in palate, the result of large doses of mercury for the cure of syphilis. She was married. Some years later she returned, with the nose in her hand, saying that she had lost her (first) husband and, marrying again, her present husband liked her better without the nose than with it. The nose was purchased for three pounds." It was presented in 1888 by Mrs Merryweather whose husband, James Merryweather, qualified M.R.C.S. in 1855.

In concluding this series of articles, I should like to express my grateful thanks to Mr S. Wood, Assistant in the Library, for reading my manuscript notes.

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Sir Benjamin Collins Brodie

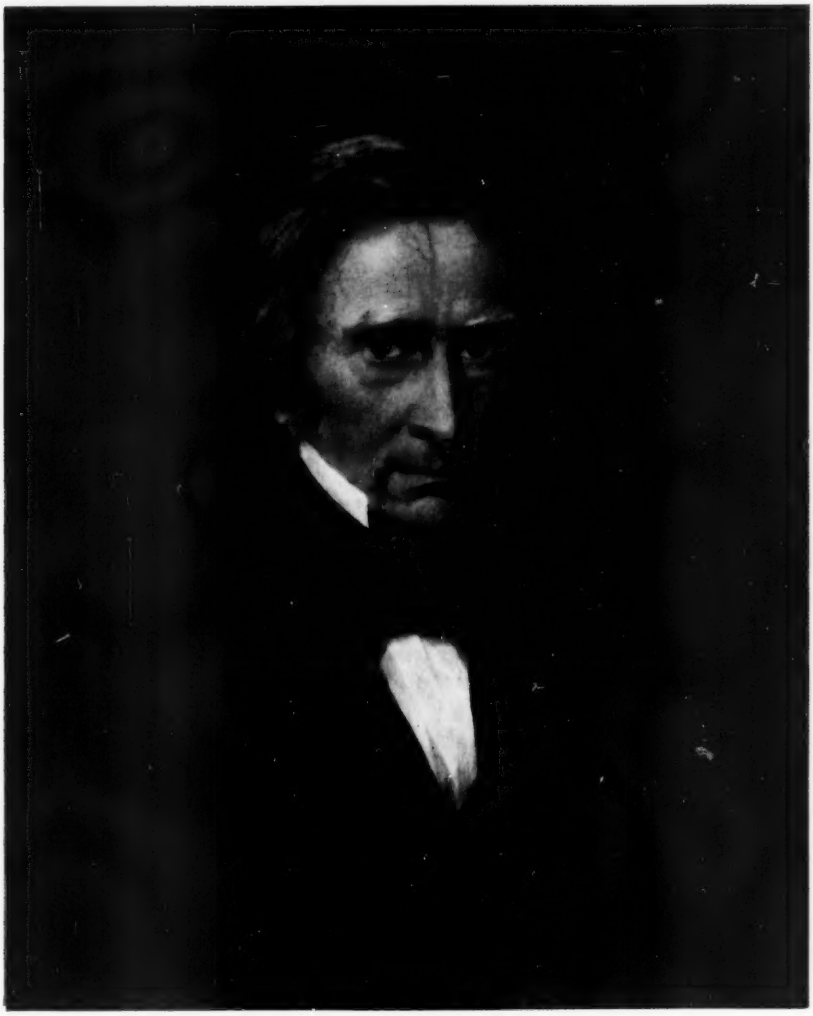
Benjamin Collins Brodie increased our knowledge of diseases of joints by his prolonged studies of their clinical and pathological manifestations.

He was born in 1783, the fourth of six children of the Rector of Winterslow in Wiltshire, the Reverend Peter Bellinger Brodie, M.A., who was educated at Charterhouse and Worcester College, Oxford, and of Sarah, daughter of Benjamin Collins, banker and printer of Milford near Salisbury. The Brodies derived from a clan of Morayshire; an Alexander Brodie of Brodie was Lord of Session in 1649 and his Jacobite descendant, also named Alexander, migrated to London in the earlier part of the eighteenth century. He married Margaret, daughter of another Stuart follower, Dr Samuel Shaw the physician. Two of their grandchildren, Lord Denman and Sir Benjamin Brodie, rose to eminence in law and medicine, one became Lord Chief Justice and the other President of the Royal College of Surgeons.

The Reverend Peter Brodie was unable to send his children to public school and university; he undertook their education himself. They certainly received a thorough grounding in the classics and mathematics, of which Benjamin gave ample proof later in life. Part of parental tutoring was the inculcation of industrious habits; the son who became surgeon of St George's was noted at the hospital for his ceaseless industry. But it was not all work, there was play-acting, in which young Denman joined, and the pastimes of the countryside. In 1798 there was a diversion of more serious intent. In that year Napoleon had an army at Boulogne watching a favourable moment for the invasion of Britain. There was considerable alarm in England, of which the still standing defensive Martello Towers of the south coast are a symbol. Brodie and his brothers raised a company of volunteers under a commission signed by George III whereby William was appointed Captain and " Our trusty and well-beloved Benjamin Collins Brodie, gent, Ensign in the company."

In 1801, at the age of eighteen years, Brodie came to London to study medicine, not that he felt any strong attraction towards the healing art at that time; he had family connections with distinguished physicians like Dr Matthew Baillie and Dr Denman. He joined Abernethy's school of anatomy; here he met William Lawrence, afterwards surgeon to St Bartholomew's Hospital, with whom he formed a lifelong friendship. The following year he attended the lectures of James Wilson at the Hunterian School of Anatomy in Great Windmill Street and worked hard at dissection. After spending nearly two years at these studies he entered St George's Hospital as a pupil of Everard Home in 1803. Early the following year his father died, leaving Mrs Brodie in straitened circumstances, dependent on a fixed income in days of high prices, war taxation and depreciation of paper currency; an economy strangely descriptive of England a hundred and fifty years on. But with austere living, saving and some sacrifice of capital she just managed to keep up supplies to her sons in mid-career.

In May 1805 Brodie became house surgeon, a post which he held for six months, when he resigned on appointment as lecturer in anatomy at the Windmill Street School. About the same time he accepted a proposal from Everard Home to become his assistant in private practice and in his researches on comparative anatomy at the Royal College of Surgeons. These appointments were of supreme importance to Brodie for, as he remarked, " These occupations afforded me the means of learning much as to my profession which cannot be learnt in a hospital; and further by initiating me in the study of anatomy and physiology generally, without limiting my views merely to that which is required for surgical practice they led me to scientific inquiries." At the College of Surgeons he was fortunate in having



Benjamin Collins Brodie
1783-1862

the help and guidance of Clift, the Conservator of the Museum, who in his youth had lived in John Hunter's home and was trained by him. Clift had an intimate knowledge of every specimen and manuscript such as no one else had.

In 1808 Brodie was appointed assistant surgeon to St George's Hospital, being attached to Everard Home; owing to the absence of Gunning, another surgeon, in the Peninsular War, Brodie and Robert Keate shared his duties. Brodie was at the hospital every day; he introduced clinical clerks on the surgical side who were taught the duty of accurate case recording; regular teaching was imparted in the wards and he delivered a course of clinical lectures on surgery, the first of their kind in a London hospital. The same year he joined James Wilson in lecturing on surgery at the Windmill Street School.

His researches at the Royal College of Surgeons and his association with Sir Everard Home and Clift brought him into intimate contact with Sir Joseph Banks, Sir Humphry Davy, Wollaston and other scientists. In 1810 he was elected a Fellow of the Royal Society and the same year delivered the Croonian Lecture " On the Influence of the Brain on the action of the Heart, and the Generation of Animal Heat." He also communicated a paper on " The effects produced by certain Vegetable Poisons." In 1811 he was awarded the Copley Medal of the Society for his physiological researches.

In 1816 he married a daughter of Serjeant Sellon who had been a barrister of a good deal of repute and the author of *Sellon's Practice*, a work much valued by the legal profession. They lived first at 22 Sackville Street, but three years later moved to a larger house in Savile Row. There were two sons and a daughter of the marriage; the elder son became a Fellow of the Royal Society and Wayneflete Professor of Chemistry at Oxford, after a notable career at Harrow and Balliol. The younger son became Vicar of East Meon.

In 1819 Brodie succeeded Lawrence as Professor of Comparative Anatomy and Physiology at the Royal College of Surgeons. He lectured on the functions of the organs of respiration, circulation and digestion, and on the nervous system. In practical surgery he was interested above everything else in diseases of joints, to which his attention was first directed when as house surgeon he dissected a specimen consisting of a pathological dislocation of the hip. He realised that when disease appeared in a joint much confusion often prevailed as to its nature. The pathology of joint disease had been neglected; there was great need of investigation, particularly of the early stage of disease. With this in mind he wrote: " I availed myself of every opportunity which occurred of making such examinations. In particular I was anxious to do this when the morbid changes were still in an early stage, and where I had the opportunity of noting the symptoms by which the incipient disease was indicated; and the knowledge thus acquired became the basis of my future observations." From the time he became assistant surgeon he kept a record of almost every patient with articular disease under his care and dissected any joint with incipient disease in post-mortem examinations of patients who had died from other causes. Brodie's researches on joint disease occupied the greater part of his professional life. In 1818 he published his great treatise on *Pathological and Surgical Observations on the Diseases of the Joints*; it went through five editions, the last in 1850. With the appearance of this work his advancement was rapid and it secured him an international reputation. It was the first serious attempt to separate the various conditions grouped together as " white swelling." He drew attention to the hysterical joint, then prevalent among young women of the more favoured class, due to mistaken ideas of physical exercise and education. He had considerable success with spinal caries by his enforced and prolonged recumbency, preferably at the seaside. He was against any attempt at correction of the kyphos, for he believed that the collapsed vertebrae provided for a more certain anyklosis. He wrote: " Without such undue interference on the part of the surgeon, the carious surface of the vertebra above will always come in contact with that of the vertebra below; and it is to the union which takes place under these circumstances, at first by soft substance, and afterwards by bony matter, and to this alone, that we are to look for the

patient's recovery. Whatever disturbs this process (and any attempt to straighten the spine cannot fail to do so) must therefore be carefully avoided."

He speaks of paraplegia as a complication of spinal caries but was able to report the good result of prolonged recumbency as follows: " Paralysis of the muscles below the seat of the disease must always be regarded as an unfavourable symptom. Yet in many instances, after being for some time in the recumbent posture, the power of the will over the muscles begins to be restored; and I have known children, in whom the muscles of the lower limbs had been completely useless, after the lapse of three or four years, to be able to walk and run and jump as well as if they had never laboured under any kind of disease."

In 1822 Brodie became surgeon to St George's Hospital; for the next eighteen years he was heavily engaged in his hospital and private practice; he lectured a great deal and continued with his physiological researches. In 1821 he attended King George IV when Sir Astley Cooper removed a sebaceous cyst. In 1828 when Sir Astley became Serjeant Surgeon Brodie succeeded him as Surgeon to His Majesty. He was in daily attendance at Windsor during the King's last illness two years later. In 1832 he became Serjeant Surgeon to King William IV and afterwards to Queen Victoria. In 1834 he was made a baronet; the same year he was admitted a member of the Council of the Royal College of Surgeons and a member of the Court of Examiners. Three years later he delivered the Hunterian Oration; he was elected President of the Royal College of Surgeons in 1844. He resigned from the staff of St George's Hospital in 1840, at the age of fifty-seven. His departure was made the occasion for the appreciation and gratitude of the profession, for his eminent services to surgery, by the presentation of the large " Brodie Medal " at a public dinner. On the obverse side is a bust of Sir Benjamin and on the reverse a female figure, emblematical of medicine, in a kneeling attitude trimming the Hygeian lamp. Lady Brodie wrote to her son saying, " The likeness is perfect, and I cannot find a fault with it." The original medal was presented to the Royal College of Surgeons by the present baronet in 1953; it was the work of Wyon of the Royal Mint.

After thirty-two years of strenuous effort at the hospital he said that, after his resignation, he never passed St George's without a sense of regret that his work there was over. To lessen this feeling he delivered a short course of lectures to the students each winter session, " generally selecting for his subject some one class of disease, and giving a more detailed history of his own experience than was possible in an ordinary course of surgical lectures." Two diseases which have perpetuated his name, Brodie's abscess and Brodie's tumour, were the subjects of lectures delivered in these courses.

BRODIE'S ABSCESS

The lecture on abscess of the tibia was delivered in the theatre of St George's Hospital on November 19, 1845. It is reported in the London Medical Gazette for 1845. He said: " In the year 1824 I was consulted by a young man, 24 years of age, under the following circumstances: There was a considerable enlargement of the lower end of the tibia, but the ankle joint admitted of every motion and was apparently sound. The skin was thin, tense, and closely adherent to the periosteum. There was constant pain in the part, generally of a moderate character, but every now and then it became excruciating, keeping the patient awake at night and confining him to the house for many successive days. It made his life miserable and his nervous system irritable: one effect of which was that it spoiled his temper and thus produced another set of symptoms in addition to those which were the direct consequences of the local malady. The disease had been going on for twelve years. He had consulted a number of surgeons respecting it, and had used a vast variety of remedies, but had never derived benefit from anything that was done. Instead of getting better, he every year became so much worse. I tried some remedies without any advantage, and at last recommended that he should lose the limb. Mr Travers saw him with me and agreed in this opinion. Amputation was performed, and the amputated tibia is now on the table. You will

see how much the lower end of it is enlarged, and that the surface of it presents marks of great vascularity. The bone in the preparation is divided longitudinally, and just above the articulating surface there is a cavity as large as a small chestnut. This cavity was filled with dark-coloured pus. The inner surface of it is smooth. The bone immediately surrounding it is harder than natural. The examination of the limb explained all the symptoms: there was an abscess of the tibia, stretching the bone in which it was formed, or rather, if I may use the expression, trying to stretch it, and thus causing the violent pain which the patient suffered. On observing these appearances, I could not help saying, that if we had known the real state of the disease the limb might have been saved. A trephine would have made an opening in the tibia, and have let out the matter. It would have been merely applying the treatment here that we adopt in the case of abscess elsewhere. You open a painful abscess of the arm with a lancet: you cannot open an abscess of the bone with a lancet, but you may do so with a trephine.

" About two years after the occurrence of this case I was consulted by another patient, 23 years of age, who had an enlargement of the upper end of the tibia extending to some distance below the knee. He suffered a great deal of pain, the part was very tender, and there were all the symptoms of chronic periostitis. I made an incision over the part, dividing everything down to the bone, and found the periosteum very much thickened. There was a new deposit of bone under the periosteum, softer than the bone of original formation. This operation, as in other cases of chronic periostitis, relieved the tension and the pain, and the patient was supposed to be cured. However, about a year afterwards, in August 1827, there was a recurrence of the pain; the enlargement of the tibia, which had in some degree subsided, returned, and it continued to increase. In the enlarged tibia there was one spot a little below the knee where there was exceeding tenderness on pressure. I need not describe the symptoms more particularly; it is sufficient to say that they bore a very close resemblance to those in the last case; the only difference being that, as the disease had been of shorter duration, the pain was less severe, and that the tibia was affected in the upper instead of the lower extremity. I concluded that there must be an abscess in the centre of the bone, and applied the trephine to the tender spot. I used the common trephine made for injuries of the head, which, having a projecting rim or shoulder, would only penetrate to a certain depth. However, it enabled me to remove a piece of bone of sufficient thickness to expose the cancellous structure. Then with a chisel I removed some more of the bone. Presently there was a flow of pus in such quantity as completely to fill the opening made by the trephine and the chisel. It seemed as if the bone had been to a certain extent kept on the stretch by the abscess and that, as soon as an opening was made into it, it contracted and forced up the matter. The patient was well from that time; the would healing very favourably, and he has never had any return of the disease . . . When the tibia is enlarged from a deposit of bone externally—when there is excessive pain, such as may be supposed to depend on extreme tension, the pain being aggravated at intervals, and these symptoms continue and become aggravated, not yielding to medicines or other treatment that may be had recourse to—then you may reasonably suspect the existence of abscess in the centre of the bone. You are not to suppose that there is no abscess because the pain is not constant; on the contrary, it very often comes on only at intervals, and in one of the cases which I have related there was, as I then mentioned, an actual intermission of seven or eight months. After the disease has lasted a certain number of years, indeed, the pain never entirely subsides, but still it varies, and there are periods of abatement and of exacerbation." He gave details of patients with similar signs successfully treated by bone trephining. He recommended the use of a small-sized trephine without rim or shoulder.

BRODIE'S TUMOUR

The lectures dealing with tumour of the breast are reported in the Medical Times for 1844. " In the present lecture I shall make some observations on the diseases of the breast, no very

clear description having been given of them, although of common occurrence. The disease to which I shall particularly refer to-day is one of considerable interest; especially so, because it is quite different from carcinoma with which it has been frequently confounded. It is not met with in hospital practice, but very often shews itself in private life, and unless I had had the advantage of seeing a large number of private patients, I should not have been able to make out its symptoms and history, as I believe I now can . . . A lady consulted me who had one of these tumours in her breast, about the size of a walnut; I punctured it with a needle first and, finding it contained serum, I laid it open with a lancet; a large quantity of fluid escaped. I then dressed it with lint to the bottom, meaning to bring on inflammation: a good deal of suppuration followed, and the wound was two months before it healed, and then the disease was apparently quite eradicated. About a year after this the patient came to me again, and I found, where I had opened the cyst, a fungous tumour as large as the cyst I had previously opened. I recommended her to have the breast amputated; the operation was performed, and we found it to be entirely made up of cysts containing fluid matter, and one of a large size as represented in the drawing on the table. From the inner surface of this cyst there projected a solid tumour, which appeared to be made up of numerous folds giving it a plicated appearance, covered by membranes continuous with that lining the cyst; and when cut into, it looked like very slightly organized fibrine . . . The disease, as I have said before, is not cancerous; but still it should be removed; because if allowed to remain, the local irritation will destroy the life of the patient; and if removed, it will not return. If you operate at all you must remove the whole of the breast, for it is no use taking away small portions. It is better to perform the operation whilst the tumour is small; nevertheless you are not to be deterred by its magnitude, because it is not in this disease as in carcinoma; there is, in fact, no danger: and I have seen a great many cases where the operation has been performed and the disease has never returned . . . I have given no name to this affection because I think it is an error of modern times to be continually giving new names to diseases, but if it must have a name, I think it should be called sero-cystic tumour."

INTEREST IN MEDICAL EDUCATION

Next to his interest in diseases of joints Brodie gave a good deal of attention to maladies of the urinary system. In pre-antiseptic days lithotomy was not without serious risks; to avoid them Civiale introduced lithotrity. Brodie was quick to appreciate the greater safety of this procedure and took a leading part in England in advocating lithotrity in place of lithotomy.

Relieved of hospital duties Brodie was able to spend more of his time at Broome Park, an estate at Betchworth, Surrey, which he purchased in 1837. Furthermore he gave more attention to medical education and reform, both of which had always interested him. In 1843 he played a prominent part in extending the constitution of the Royal College of Surgeons, whereby a new order of members under the title of Fellows, qualified by a higher standard of examination, was to be established. The object of this institution was " to insure the introduction into the profession of a certain number of young men who may be qualified to maintain its scientific character, and will be fully equal to its higher duties as hospital surgeons, teachers and improvers of physiological, pathological, and surgical science afterwards." A new charter enabling the College to carry out this reform was granted by the Crown in 1843. By this instrument all power of election was vested in the Fellows; retention of office for life by examiners and members of Council was abolished; the offices of president and vice-president were restricted to members of the Court of Examiners.

With the passing of the Medical Act in 1858 the General Medical Council of Medical Education and Registration became established. The Council was authorised to require from licensing bodies information as to courses of study and examinations and to visit and inspect examinations. A register was to be established of persons holding a diploma or licence from

a licensing body after examination. Brodie was chosen to be the first president of this council. A few days later he reached the climax of his career when he was elected President of the Royal Society, a position he filled with dignity and distinction. It was particularly gratifying to him that his heir occupied the chair of the Chemical Society at the same time and that he had previously been awarded the Royal Medal of the Royal Society.

In his last years Brodie wrote a short work on metaphysics entitled *Psychological Inquiries*. It bears the influence of Berkeley and is cast in the form of a dialogue; it first appeared in 1854 and passed through four editions. He treats the question of the existence and creative energy of God as settled and teaches that mind and matter are different in their nature, so that mental phenomena cannot be regarded as the product of material forces. He attributes great importance to the imagination and its training by education; the possession of this great faculty distinguishes man from the lower creatures; men live in the world of the imagination as much and as truly as they do in the world of sense. All philosophies rest on certain assumptions and one such for Brodie was " the existence of one's own mind is the only thing of which one has any positive and actual knowledge." Regarding personal conduct he dwells on the necessity for " another quality for which he can find no other English name than that of humility, though that does not exactly express the meaning, that quality which leads a man to look unto himself, to find out his own deficiencies and endeavour to correct them, to doubt his own observations until they are carefully verified." This in effect is an echo of Pauline teaching, " For I say, through the grace given unto me, to every man that is among you, not to think of himself more highly than he ought to think."

Brodie's personal appearance was striking, though not perhaps handsome; his frame was slight and small but he had consuming energy. In private life he was known for his playful humour and fund of anecdote. As a lecturer " none who heard him can forget the graphic yet artless manner in which, sitting at his ease, he used to describe minutely what he himself had seen and done under circumstances of difficulty, and what under like circumstances he would again do or would avoid." When Astley Cooper retired Brodie became his natural successor as the leading surgeon in England, added to which he had more intimate contact with leaders of science and literature. He was a man of great erudition; a rare combination of surgeon, scientist and philosopher. He had a Hunterian attitude towards surgery in that he regarded scientific research to be the handmaid of practice. In particular he clarified our knowledge of joint disease. He made a lasting contribution towards medical education whereby preliminary instruction in the arts and professional training were greatly improved. By his advocacy of reform of the Royal College of Surgeons he helped to raise its status as a governing body and enhanced the quality of those whom it approved to practice surgery.

For the last few years of his life he suffered from double cataract, for the relief of which Sir William Bowman operated. In July 1862 he began to complain of pain in his right shoulder, caused by malignant disease; he died on October 21. Twenty-eight years before he had fallen from a pony and dislocated this joint. Lady Brodie had passed away the previous year.

ARTHUR ROCYN JONES.

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[We are grateful to Capt. Sir Benjamin Collins Brodie, 4th Baronet, for permission to reproduce the portrait of his great-grandfather painted by G. F. Watts.]

JACQUES CALVÉ
1875–1954

In the years between the two world wars, when spectacular developments were taking place in orthopaedic surgery in great Britain, three continental surgeons formed close ties of friendship with their British contemporaries—Mürk Jansen, Vittori Putti, and Jacques Calvé. All three looked to Sir Robert Jones as their leader, and contributed to the Birthday Volume (1928). With the passing of Jacques Calvé another of the few remaining links with the great master is severed.

Calvé will long be remembered as one of the most distinguished exponents of French orthopaedics, and more especially for his illuminating contributions on the treatment of bone and joint tuberculosis. After resident hospital appointments in Paris he became an assistant of the great pioneer Ménard who for so many years directed the Maritime Hospital at Berck, and it fell to Calvé to present the principles and teaching of his master in modern perspective. This he did in a succession of articles and monographs. Many of these were written in collaboration with his colleague, Marcel Galland, whose mechanical ingenuity in the devising

of instruments and operative techniques was in striking contrast with Calvé's essentially conservative approach to the long-term problems of tuberculous disease of the spine and larger joints. After Ménard's retirement Calvé organised a new hospital—La Fondation Franco-Américaine de Berck. As the name suggests, this was launched with funds collected by American residents in France. Madame Calvé herself was an American lady and the daughter of a regular officer in the United States Army. Of Calvé's contributions to orthopaedic knowledge, a few stand out in bold relief—his independent description of pseudo-coxalgia (to be known later as Legg-Calvé-Perthes disease); his article on vertebral osteochondritis in the Robert Jones Birthday Volume; his pioneer attempts to relieve tension in Pott's paraplegia by tapping the intraspinal abscess through an intervertebral foramen. In a letter to the writer of this memoir dated August 3, 1929, there can be found the following paragraph: " Je trouve que tous ces procédés de greffes extra-articulaires iléo-trochantériennes sont insuffisants et j'étudie maintenant, comme je vous l'ai dit, un procédé qui me permettra de placer un greffon inter-fémoro-sciatique. J'espère d'ici peu vous envoyer des documents intéressants à ce sujet."

Calvé was a man of gracious bearing, tolerant, kindly, and a delightful host. After the liberation of France he went to live in the United States of America but returned to Berck in 1953 in failing health, to die in his old hospital. H. P.

SERGEI YUDIN

Hon. F.R.C.S. (Eng.), Moscow

1890-1954

Professor Yudin who was chief surgeon of the Sklifosovski Hospital for Traumatic Diseases in Moscow and Director of Surgery in the Moscow Postgraduate Medical School died a few weeks ago. He was a bold, brave and resourceful surgeon—and a bold, brave and kind man. His particular experience was in abdominal surgery and he numbered his gastrectomies by the thousand, all done with spinal anaesthesia. He had an incredible series of cases of replacement of the oesophagus destroyed by sulphuric acid—this acid being commonly placed for hygrosopic purposes in tumblers between the double windows of houses in Moscow in the desperately cold winter; he transplanted the jejunum in front of the chest wall and prepared the track with enormous spade-like instruments and they too were passed with local anaesthesia or perhaps with no anaesthesia at all.

He played an essential part in the development of emergency traumatic services in the capital city of Moscow and was a pioneer in the transfusion of cadaveric blood. He made a cadaveric blood-bank long before anyone else talked of " banks." He made important contributions on the surgical excision of gun-shot wounds and practised wide excision not only within the first few hours but also in some cases after many days or weeks. He did his work right up to the front line of the Russian-German battles of the recent war.

The system of civilian emergency service which he developed with its centre at the Sklifosovski Hospital was no less efficient than that of most fire-brigade services in other

countries; with the simple press of a button, or the ring on a telephone, an ambulance arrived so that within a few minutes the patient was under the personal supervision of Yudin himself.

When those of us who were members of the British-American-Canadian Surgical Mission visiting Russia in 1943, including Gordon Taylor, Rock Carling, Wilder Penfield, and others, we found Yudin one of the most inspiring and stimulating of all the surgeons we met. It was our great honour to present him on that occasion with the Honorary Fellowship of the Royal College of Surgeons of England. We deplore his loss—it is a great loss. R. W.-J.

ALEXANDER JUETT
1887-1953

Alexander Juett died on May 19, 1953, at the age of sixty-six, after a long illness. Elected to a Rhodes Scholarship, he went up from Christian Brothers College, Perth, to Brasenose College, Oxford, to read medicine. He was placed in the second class in physiology in 1910, elected to a Hulme Research Scholarship in 1911 and qualified B.M., B.Ch. in 1913 after three years at the Middlesex Hospital. He became head of the Government Hospital at Nannine, Western Australia, on his return to Australia in 1913 and married the next year.

He served in the Australian Army Medical Corps throughout the first world war, was mentioned in despatches and badly gassed in France. At the end of hostilities he was Lieutenant-Colonel in charge of the medical side of the Repatriation Department in Fremantle. On demobilisation he began practice in Perth, and thereafter steadily became one of the most prominent, and certainly one of the most selfless, orthopaedic surgeons in Western Australia. He was the pioneer orthopaedic specialist in the State and had to face the opposition customary in those days. This opposition he steadily overcame without creating enmity, and it was not long before his colleagues recognised his superior merits. He initiated the orthopaedic clinics at the Children's Hospital and the Perth Public Hospital, and at the time of his death was Consulting Honorary Orthopaedic Surgeon to both. He was a foundation Fellow of the Royal Australian College of Surgeons and a foundation Member of the Australian Orthopaedic Association. In the second world war he was a consultant, with the rank of Major, to the Australian forces.

Every year he personally conducted the medical examination of Rhodes Scholar candidates in Western Australia, and among other organisations—and these were widespread—to which he insisted on giving his services free, was the Fairbridge Farm School at Pinjarra. He was Honorary Surgeon to the Maimed and Limbless Ex-Servicemen's Association and took a great personal interest in each individual member who needed his attention. All this while he was himself a constant sufferer from the after effects of being gassed. He was a genuinely unselfish man. He is survived by a widow. R. McK. H.

WILLIAM FRANCIS HERLIHY
1923-1953

The foundations for a successful surgical life are devotion and industry to a degree to which few can aspire. Bill Herlihy was one of these few, and his untimely death came as a shock to his friends and colleagues at a time when they realised that his future was assured.

He graduated at Sydney University in 1945, and spent two years at The Royal Prince Alfred Hospital, where he developed his interest in orthopaedic surgery. He then spent three years as a teaching fellow in the Anatomy School of the University, and his thoroughness and enterprise were rewarded when he obtained his M.D. for a thesis on the role of the vertebral veins. He passed his Part I F.R.A.C.S. in 1949 with ease and then went to England to work at the Derbyshire Royal Infirmary. He became a Fellow of the Royal College of Surgeons of England in 1951, and continued working in Derby as orthopaedic registrar for about a year. About this time he became ill. He was flown home to Australia, and died shortly afterwards.

H. R. T. H.

Bill Herlihy was one of the best men I have ever known. Within a few days of his appointment in 1950 as house surgeon to the senior surgical unit we realised that this young Australian surgeon was a man of outstanding character and ability. His modesty and charm, his quiet humour and integrity endeared him to all. When he returned in 1952 as orthopaedic registrar, the staff were delighted that he had chosen to work with us again.

Bill knew God as a living God who touched life at every turn. His faith bore him triumphantly through that heart-rending time when he realised that his service here was ending. His courageous bearing, and his quiet acceptance of the future exerted a deep and lasting influence upon those who knew him. He will not be forgotten. R. G. P.

PROCEEDINGS AND REPORTS OF UNIVERSITIES COLLEGES, COUNCILS AND ASSOCIATIONS

GREAT BRITAIN

BRITISH ORTHOPAEDIC ASSOCIATION

ANNUAL MEETING

The spring meeting of the British Orthopaedic Association was held at the Devonshire Royal Hospital, Buxton, on May 6–8, 1954, under the presidency of Professor Bryan McFarland.

Syme's amputation—*Mr J. H. Shelswell* (Stanmore) gave an account of the current opinion regarding Syme's amputation, an operation with a much better reputation in Canada than in this country. He had reviewed the Syme's amputees from the material available at Roehampton; of 534 cases the 302 done before 1939 were chosen for assessment and a follow-up on sixty-six of these was done. Two-thirds had had no significant trouble; 23 per cent, including immediate failures, needed re-amputation, and as *Mr Leon Gillis* (London) pointed out in the subsequent discussion, this is no higher than follows the standard below-knee amputation. Causes of failure were assessed. The operation had no place in the neuropathic limb nor in those with vascular failure, and it was seldom indicated in women, who had no means of concealing the necessarily bulky and obvious ankle joint in the prosthesis. But for the working man it was a most satisfactory operation, enabling him to stand and walk for long hours and even to play games. It was particularly advantageous for the double amputee, and he concluded that a properly done Syme's amputation was an excellent and long-lasting operation.

Review of 650 arthroplasties of the hip—*Mrs M. M. Shepherd* (Birmingham) in a fine and painstaking work gave a review of 650 arthroplasties of the hip, followed up for a maximum of six years from operation, which in almost all cases were either of the metal cup or acrylic head type. They were assessed according to pain, range of movement, the patient's evaluation, and the objective estimate of function. Out of the great mass of figures available certain facts emerged. Excepting loss of pain, stability and satisfactory unconscious control of the hip were of greatest value to the patient, but the better the range the better, on the whole, was the result. Even so the mobility index (Gade) was not much worse in the poor than in the excellent results. The presence of slight residual fixed flexion seemed to give improvement, but transplantation of the trochanter delayed a good result. The post-operative slackening of the short " stability muscles " might be of significance in this connection, and to avoid shortening of the neck there might be a case for a thicker cup. With regard to durability, cup arthroplasties go on improving up to four years, when 45 per cent had good or excellent results; after five years 54 per cent had poor results. The Judet arthroplasty was characterised by quicker recovery, but deteriorated sooner and progressively. Not all arthroplasties, however, deteriorated in later years, some with no apparent peculiarity retaining their excellence unchanged for many years. Mrs Shepherd believed that arthroplasties with no inserted foreign material lasted best, then those with unfixed inserts such as cups, and lastly those with fixed prostheses. The percentage of good results was higher in unilateral than in bilateral cases, and in the latter was higher when only one hip was operated on. The massive material embodied in this impressive paper cannot be summarised satisfactorily in a brief report.

The management of the broken acrylic head—*Mr K. H. Pridie* (Bristol) expressed his dissatisfaction with the Judet arthroplasty which he maintained should be reserved for those with a brief expectation of life. In his hands 5–10 per cent would fracture their prostheses. Even at a year marked flattening and wear of the head was to be seen, and he thought lack of this flattened facet was evidence that the prosthesis was rotating in the femoral neck. In his survey 20 per cent had loose prostheses, though a period of plaster immobilisation might fix them again. As an alternative to replacing the head when fracture of the prosthesis or a poor result necessitated further operation he considered the Girdlestone " pseudarthrosis " satisfactory.

Kypho-scoliosis—*Mr J. I. P. James* (London) called attention to the lack of British work on the subject of kypho-scoliosis although there was an extensive German literature concerning it. Apart from those (where the scoliosis was usually mild) occasionally seen in Pott's or Scheuermann's disease, he classified his twenty-seven cases into 1) congenital, 2) those associated with otherwise typical idiopathic scoliosis, and 3) those seen with neurofibromatosis. In the first group radiographs or operation displayed the malformation, but even early films of the second group showed no

vertebral abnormality. Most congenital cases occurred in the thoraco-lumbar region, but there was a small group in the cervico-thoracic region. The deformity was progressive and severe, and might cause paraplegia. Early operation was indicated but fusion in these cases was difficult. The severity of both elements of the deformity had hitherto confused them with severe simple scoliosis.

Wedge excision for scoliosis—*Mr R. Roaf* (Liverpool) reported an operation of wedge excision of the vertebrae for scoliosis. He pointed out that ordinary " correction " affected the transitional vertebrae at each end of a curve and left the central fixed portion unchanged. In the past there had been general fear of direct operation emanating from the difficulties encountered in excision of hemivertebrae. With experience of antero-lateral decompression, skilled anaesthesia, and plaster work of the highest order, he had found no great difficulty in doing what was really a lateral osteotomy of the spine. At the apex of the curve the posterior parts of two ribs were removed; from the two underlying vertebrae were removed the transverse processes, pedicles, the intervertebral joint, and part of the laminae on that side. With the aim of a subperiosteal enucleation, a wedge of bone was removed from the bodies of the two vertebrae, including in the wedge the intervening disc. A few days later correction was obtained in a Risser jacket and treatment proceeded on usual lines. Ideally bony union between the vertebral bodies occurred, but in the event of failure later spinal fusion might be needed. It was stressed that this was not an easy operation for routine use but was offered tentatively for curves that did not respond to other methods.

Debate—A debate was held on the motion: " *In the opinion of this house all methods of arthroplasty of the hip have failed to achieve their purpose.*" In spite of spirited support from the openers and the considerable number who finally voted in agreement with it few could be found to speak wholeheartedly in its favour, and the motion was lost by a substantial majority.

Mr K. I. Nissen (London), proposing the motion, based his attack on hip arthroplasty on four counts: 1) the serious post-operative complications that might occur; 2) the early deterioration of the results; 3) the expense of the seemingly endless physiotherapy required, and 4) the faulty conception of the operations due to ignorance of the true pathology. One concept of vascular degeneration in the femoral head had been exploded by recent work at Oxford. Any pain-relieving operation reduced the blood supply of the hyperaemic head, but arthroplasty interfered with it too extensively. The more British operations of McMurray's displacement osteotomy, Girdlestone's pseudarthrosis, or arthrodesis could be relied on to give equivalent or better results. The reason these operations were not in favour with younger surgeons was that they had little experience of them, and since the result was permanently good the patients found no need to return to the surgeon. In most arthroplasties of all types the head eventually disappeared to leave a form of pseudarthrosis.

Mr W. A. Law (London) opened against the motion. After saying that there was no universally applicable hip operation, he enumerated the essential requirements of a good arthroplasty: 1) a joint must be made; 2) the pain of the arthritic joint must be alleviated and that produced later from over-fatigue of the controlling muscles must be limited; 3) fixed deformity must be corrected; 4) the new joint must be stable; and 5) an adequate range of movement must be produced though a stable joint with small range was greatly preferable to an over-free joint in which muscle control was poor and fatigue-pain therefore marked. With these criteria he maintained that cup arthroplasty was a good operation, the good results of which lasted better than Mrs Shepherd's investigation suggested (*vide supra*). Patients had asked him to do an arthroplasty on their second degenerating hip five or ten years after one had been done on the first hip. But he stressed that careful selection of patients was essential; obesity was not a contra-indication but one must be satisfied that the patient had the morale to pursue the necessarily arduous after-care, and he mentioned private patients favourably in this connection. They must be warned of and understand the limitations of the result to be expected. The essential exercises could perfectly well be done at home but circumstances often made prolonged supervision in the physiotherapy department essential. He did not look on cases needing revision as " failures," which was suggested by Mr Nissen to be their proper description, but considered revision as an essential part of the treatment of the rheumatoid hip.

Mr N. Capener (Exeter) seconded the motion. He said that we had not yet overcome the difficulties of certain essential mechanical and biological conditions: 1) the new joint surfaces must have congruity and the barrier to fusion must be neither so hard as to cause bony atrophy nor so soft as to be worn away by friction; 2) there must be proper lubrication, and 3) the problems of leverage and adequate strength of prostheses must be solved. Our present methods were incompatible with these requirements. He estimated the cost to the nation of an arthroplasty at £200, which he looked on as very expensive for an operation doomed to failure. According to Mrs Shepherd's figures one could not prophesy more than a 50 per cent chance of success at four

years for cup arthroplasty or at three years for prosthesis arthroplasty, which on the basis of the life-expectancy charts of insurance companies should confine the former operation to the over-80's and the latter to the over-90's! He believed that the place for cup arthroplasty was a very small one, and he found no place for prosthesis arthroplasty.

Mr Lloyd Griffiths (Manchester) seconded for the opposition with characteristic verve. He denied that the traditional British operations relieved pain, and compared their results with those obtainable by taking the local waters. Arthroplasty was in a state of rapid evolution and even the best of operations, like aeroplanes, were liable to temporary "grounding." He considered the results even now as well worth while and pointed out that little progress would be made if surgeons must always await exact pathological elucidation of the problem.

Mr R. G. Taylor (Oxford) said that good results could be obtained from a properly done Girdlestone's pseudarthrosis. *Mr W. E. Tucker* (London) thought it advisable to make patients write down their pre-operative complaints as objective evidence for comparison with their later troubles, and *Mr H. Osmond-Clarke* (London) said that arthroplasty had no place in the young patient.

Professor Merle d'Aubigné (Paris) thought that all the failures of arthroplasty were due to technical errors. It took perhaps 200 arthroplasties to learn the art. He reported a much lower failure rate than the British figures, and stressed the importance of providing the correct length of neck and of correcting anteversion. He thought the results on the whole did not deteriorate in later years; indeed some cases classed as only "fair" a year after operation became "good" with further passage of time. *Mr K. H. Pridie* (Bristol) supported the advantages of the d'Aubigné type of prosthesis. *Sir Reginald Watson-Jones* (London), although maintaining that arthrodesis was incomparably the better operation in the young, said he would vote against the motion as it was worded. *Mr John Charnley* (Manchester) spoke of the advantages, essentially of principle rather than technique, of his operation of central dislocation of the hip and thought that arthrodesis was a good operation even in the elderly, particularly in those of wiry build.

Dr Robert Judet (Paris) gave figures to illustrate the good results of acrylic head arthroplasty and recommended the new prosthesis with an oblique base. He pointed out that the crushed cancellous bone around the stem of any prosthesis was in a state comparable to a bone graft and that therefore weight bearing should be delayed for two months until revascularisation of the trabeculae was advanced. He thought that acetabular changes resulted from incongruity of the prosthesis, which should be of exactly the right size. He said that fractures of the prosthesis were now seldom seen in France and he attributed this to a better acrylic resin. *Mr J. H. Mayer* (Tunbridge Wells) thought the poor results were due to failures on the part either of the surgeon or of the material and advocated the use of metal prostheses rather than acrylic resin.

Mr W. A. Law (London) summing up for the opposition, said that we should continue to aim at the ideal of a mobile hip even in the young. *Mr K. I. Nissen* (London) summed up for the motion.

The use of electromyographic currents for the operation of prostheses—*Dr J. Joseph* (London), *Mr A. Nightingale* (London) and *Mr C. K. Battye* (London) demonstrated the prototype of an invention of *Professor J. Whillis*, by which in amputees the electromyographic currents produced by the muscles in the stump could by suitable apparatus be made to work a switch and thus electrically motivate a prosthesis.

Review of sixty patients with subcapital and transcervical fractures of the femur treated by primary replacement with Judet's acrylic prosthesis—*Mr C. M. M. Murray* (Portsmouth) presented a review by *Mr G. N. Golden* (Guildford), *Mr A. G. Ord* (Portsmouth) and himself of sixty cases of fractured neck of femur treated by primary replacement with Judet's acrylic prosthesis. There was no immediate operative mortality but seven patients died while still in hospital. Later complications included two dislocations, two fatal cases of infected haematoma, one broken prosthesis, late ossification in the capsule, and late varus deformity. At eighteen months over 80 per cent had a satisfactory result, and he recommended the operation for elderly patients, especially those with high or vertical fractures.

The use of the acrylic head prosthesis in high fractures of the femoral neck—*Mr J. C. F. Cregan* (Manchester) reviewed sixty-five cases of high fracture of the femoral neck similarly treated. In contrast to satisfactory immediate results, by the third year 85 per cent suffered increasing pain and disability, and by the fourth year results were even worse. He thought that the integrity or otherwise of the region of the calcar femoralis had an important bearing on these results. *Mr K. H. Pridie* (Bristol) pointed out that with a Smith-Petersen nail 50 per cent of patients at five years had a hip indistinguishable from normal, and deplored the use of an acrylic head as immediate treatment, a view supported by *Professor Merle d'Aubigné*. *Dr Robert Judet* confined his recommendation of the operation in this connection to the very old.

Wounds of the hand—*Professor Michael Mason* (Chicago) discussed the importance of primary closure of wounds of the hand, the only exceptions being those due to bites, and to war wounds when early evacuation was necessary. He illustrated the excellent results that could be obtained by the judicious use of the various methods of suture and grafting.

Discussions and Demonstrations

Sarcoma of femur—*Mr F. Radcliffe* (Kettering) reported a sarcoma of the lower end of the femur for which high amputation had been done in 1950. A solitary metastasis appeared in the left lower lobe of the lung in 1951. In 1952 this was enlarging but still solitary, so a lobectomy was performed. The patient was reported to be still well. He also reviewed the operation of scapulectomy and reported a successful case performed for sarcoma.

Tuberculosis of the hip—*Mr H. R. Lunt* (Derby) gave a demonstration of the results of treatment of tuberculosis of the hip. His aims had been a shorter stay in hospital, a greater range of movement, less epiphysial dysplasia, and less shortening. Stressing the destructive effects of pus left undrained, he recommended that, after suitable antibiotic therapy and conservative treatment until the most active stage was past, the lesion should be decompressed and as much as possible of the necrotic material removed. He recommended dosage of streptomycin 10 milligrams, P.A.S. 100 milligrams, and either I.N.A.H. 4 milligrams or Marsalid 2·5 milligrams per pound of body weight daily. When the femoral head was subluxating he had used a shelf operation, and in order to reduce the ill-effects of non-weight-bearing and lack of muscle tension on the epiphyses at the knee he applied skin traction to the legs of patients in a plaster shell only above the knee, which was itself left free.

Injuries of the hand—*Mr R. G. Pulvertaft* (Derby) gave an impressive demonstration of the results obtainable in injuries of the hand. The basic principles of his methods embodied: 1) immediate toilet of the wound; 2) fixation of fractures by internal methods when necessary; 3) primary tendon repair when there were no doubts regarding the cleanliness of the wound; 4) late nerve suture; 5) complete closure of the skin covering; and 6) reduction of the reactionary swelling.

CLINICAL MEETING AT BIDDULPH GRANGE ORTHOPAEDIC HOSPITAL

The Association spent a delightful afternoon at Biddulph Grange Orthopaedic Hospital, where Sir Harry Platt, Mr Denys Wainwright and Mr Stanley Walker had arranged a clinical demonstration.

Sir Harry Platt had collected a remarkable series of bone tumours which were as usual beautifully displayed. In addition he illustrated clinically some problems in the treatment of congenital dislocation of the hip.

Mr Denys Wainwright showed patients illustrating a large variety of conditions. Among the most interesting examples the following were outstanding: a shelf operation for old septic arthritis of the hip in infancy; displacement osteotomies for old unreduced congenital dislocation of the hip; chondromatosis of the elbow joint; tuberculous lesions treated with antibiotics; slipped upper femoral epiphyses; reconstruction of the tibia; and two groups of patients with osteoarthritis of the hip, contrasting acrylic replacement arthroplasty with displacement osteotomy. This last demonstration attracted much attention.

Mr Stanley Walker also demonstrated a large variety of conditions among which were some patients illustrating the use of the intramedullary nail; a patient with multiple spontaneous fractures of the spine; subluxation of the atlas complicating ankylosing spondylitis; bilateral congenital dislocation of the knee joint; and recurrent mataphysitis affecting twins.

Alderman Percy Williams, chairman of the Stoke-on-Trent Hospital Management Committee, Mr Donald Bates, chairman of the Biddulph Grange Orthopaedic Hospital, and Miss Cleator, the matron, entertained the Association to tea and also acted as guides in taking parties round the extensive grounds which were beautifully laid out to illustrate different types of classical gardens. The Chinese garden, in which the " willow pattern " is reproduced to the minutest detail, attracted particular attention. The weather was fine and all enjoyed themselves.

ARRANGEMENTS FOR FUTURE MEETINGS

The autumn meeting of the Association will be held in London on October 22 and 23, 1954, with an Instructional Course on October 21.

The 1955 spring meeting will be held in Paris in conjunction with the French Orthopaedic Association, probably during the first week in May.

ROBERT JONES GOLF CUP—MAY 1954

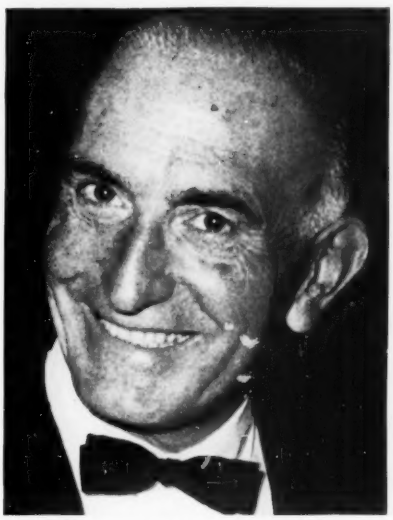
Play for the Robert Jones Golf Cup is usually favoured by good weather. This year fortune deserted us and competitors faced cold, wet and windy conditions on the afternoon of May 6 at the Cavendish Club, Buxton. As a result the scores were higher than usual but a very worthy winner was produced in Mr R. F. O'Driscoll of Dublin who did 85−8=77. The runner up was Mr A. B. McCulloch of Bishop Auckland with a score of 99−20=79. The popularity of the competition continues to increase and the record number of thirty-one competitors, including the president of the Association, took part.

The evening before the competition an informal dinner was held for golfing members of the Association. Mr W. Gissane of Birmingham, the Captain of the Golf Section, was in the Chair and proposed that Mr Norman Roberts of Liverpool should succeed him in 1954–55. He pointed out that Mr Roberts was the present Captain of the Royal Liverpool Golf Club at Hoylake and congratulated him on being accorded one of the highest honours in golf in England. Mr Roberts's election was acclaimed and the new Captain replied in his usual facile style.

As the spring meeting is to be held in Paris in 1955, it was decided to postpone play for the Robert Jones Cup next year until the autumn meeting in Liverpool. The Competition will be held at the Royal Liverpool Golf Club and it is hoped to arrange a dinner afterwards in their historic clubhouse.

HONORARY FELLOWSHIP

Professor José Valls—Honorary fellowship of the British Orthopaedic Association is a closely guarded honour, but last year it was conferred by unanimous vote upon José Valls, of Buenos Aires, who is not only a great leader in his own city, but is of such renown that he may be said to represent South and Central America just as Putti represented Italy and Europe, and even as Robert Jones represented Britain—each in his own day. Valls is a Corresponding Editor of this Journal, and he attended the joint conference of orthopaedic surgeons of the English-speaking world in London in 1952. The fact is that he speaks English as well as anyone, but can also tell good stories in the idiom of any one of a dozen different languages—all with equal effect. He makes great company, as he did at the joint meeting of the Brazilian and Latin-American Orthopaedic Associations in 1953, and no doubt will continue to do wherever orthopaedic surgeons may meet.



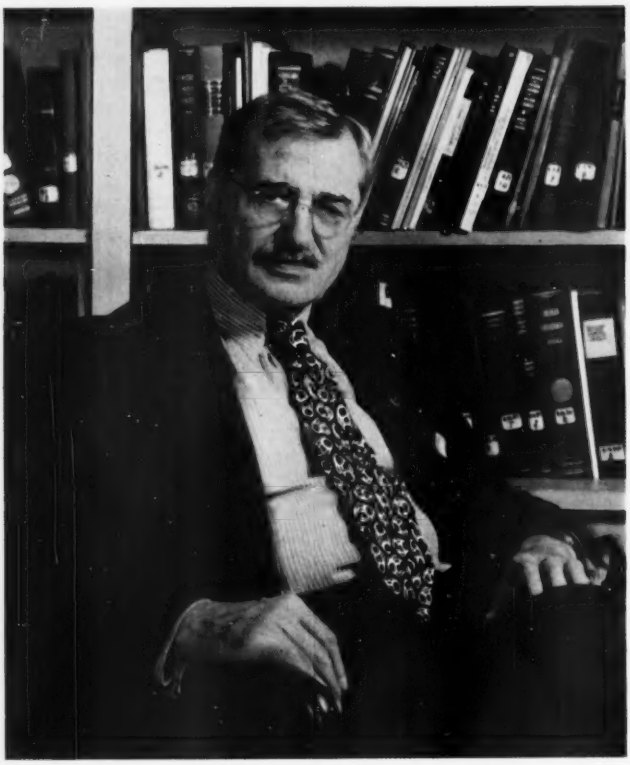
José Valls, Buenos Aires, Honorary Fellow of the British Orthopaedic Association.

ROYAL COLLEGE OF SURGEONS OF ENGLAND

CONFERMENT OF HONORARY FELLOWSHIP

At a meeting of the Council in May 1954 Honorary Fellowship of the Royal College of Surgeons of England was conferred upon Dr Arthur Steindler of Iowa City, United States of America, and Dr G. Gavin Miller of Montreal, Canada.

Dr Arthur Steindler—Steindler is a name known to surgeons the world over and suggests to them not only a particular technical procedure, but the application of a principle, namely that of the sliding of muscular origins towards their insertions so as to undo contractures and maintain and improve function. It is equally as applicable to the front of the thigh and to the flexor aspect of the forearm as to the sole of the foot. The originator of this principle is a retiring, quiet man—more at home perhaps in his library with his books, or in his clinic with his patients than on the



Dr Arthur Steindler

public platform—whom the Council of the Royal College of Surgeons of England were very pleased to honour by recently conferring on him the Honorary Fellowship of the College.

His work has been done in the United States, in Iowa City whence he travelled after qualifying in Vienna in 1902. In Iowa, as Professor of Orthopaedic Surgery and visiting surgeon to a number of hospitals, he has brought renown to the University and the city and, because of it, many visitors to his clinic.

Fame rests lightly on this home-loving little professor whose quiet and courteous charm is an endearing feature of his character which those who have had the privilege of knowing him perhaps remember best. Lambert Rogers.

Dr G. Gavin Miller

Dr G. Gavin Miller—Dr Miller was born in England in 1892 but he has spent the whole of his professional life in Montreal after graduating from McGill University. Until recently he was Surgeon-in-Chief at the Royal Victoria Hospital, and Professor of Surgery and Chairman of the Surgical Department at McGill University, and he holds appointments at a number of other Montreal hospitals. He is a member of the Council of the Royal College of Surgeons of Canada and a former vice-president and a governor of the American College of Surgeons. Miller's present surgical interest lies mainly in the field of abdominal and rectal surgery, where he has developed, among other operations, the technique of one-stage colectomy with ileostomy as a primary procedure for ulcerative colitis. For many years he has been actively engaged in teaching, and shared responsibility for the development of the present five-year Diploma Course in Surgery in the teaching hospitals of McGill University.

ELECTION TO FELLOWSHIP

Professor Joseph Trueta—As a member of twenty years' standing Professor Joseph Trueta has been elected to Fellowship of the Royal College of Surgeons of England. Born in 1897 in Spain, he spent the early years of his professional career in Barcelona, where he became professor of surgical pathology and chief surgeon of the largest hospital in Catalonia. He came to England in 1939 and joined the Staff of the Wingfield-Morris Orthopaedic Hospital, Oxford. He was elected Nuffield Professor of Orthopaedic Surgery in the University of Oxford in 1949.

Professor Joseph Trueta

UNIVERSITY OF OXFORD

NUFFIELD ORTHOPAEDIC CENTRE

Since the last report on the activities of this Centre the laboratories and the animal house for experimental surgery have been completed and brought into use for the investigation of several problems of orthopaedic interest, particularly the blood supply of the hip joint and the etiopathology of osteoarthritis; some of the results of these investigations have been published in this Journal. The experimental and clinical investigation on vascular factors influencing bone growth have continued and are now in course of publication.

A study of the vascular changes in experimental osteochondritis was undertaken by the Girdlestone Scholar. The Nuffield Orthopaedic Scholar has concluded the part of his research on the blood supply of the experimental callus of fractures; this work is now ready for publication. As a consequence of the finding of intense vascularisation in the neck and head of the osteoarthritic femur, methods to decrease this hyperaemia are now being investigated in man.

The study of the part that open reduction may play in the treatment of congenital dislocation of the hip has continued. An analysis has been made of the late results of more than 300 cases of scoliosis treated in this Centre during the last twenty years. To this study, which will soon be published, another Nuffield Orthopaedic Scholar has contributed.

Lectures—the following " Thursday Lectures " have been given at the Centre: Dr H. L. Jaffe (New York), " Solitary Fibro-Osseous Lesions of Bone and their Relation to Fibrous Dysplasia "; Professor R. Merle d'Aubigné (Paris), " The Late Results in the Treatment of Hip Conditions by Arthroplasty with Inert Prostheses "; Professor Bryan McFarland, " Treatment of Poliomyelitic Deformities of Feet in Children "; Mr H. J. Seddon, " Colonial Medicine "; Sir Harry Platt, " The Significance of Anatomical Findings in Open Operations in Congenital Dislocation of the Hip "; Mr H. Osmond-Clarke, " Cervical Spondylosis "; Dr J. F. Brailsford, " The Manifestations and Complications of Paget's Disease "; Mr R. G. Pulvertaft, " The Problems of the Injured Hand and its Repair "; Mr John Charnley, " Compression in the Union of Bone "; Mr Norman Capener, " Evolution of Lateral Rachotomy "; Mr Philip Wiles, " Posture "; Dr A. G. S. Hill, " Current Views of the Aetiological and Therapeutic Problems of the Chronic Rheumatic Diseases "; Mr G. Platt, " Recurrent Dislocation of the Elbow and its Treatment "; Mr E. W. Somerville, " Congenital Dislocation of the Hip "; Dr A. X. Cavadias, " The Vasculature of Bone and the Healing of Fractures: an Experimental Study "; Mr T. H. Morgan, " The Long Term Results of Spinal Fusion in Scoliosis "; Mr M. H. M. Harrison, " Recurrent Dislocation of the Patella and its Treatment "; Professor J. Trueta, " A Report on the Last Latin-American Congress of Orthopaedic Surgery held in Rio de Janeiro "; " Present Views on Poliomyelitis "; " Santiago Ramon y Cajal and his Contribution to Medicine "; " Michael Servetus and the Development of Modern Science " and " A Symposium on Poliomyelitis " (opener). The lectures have made an appeal to orthopaedic colleagues from as far afield as Nottingham, Bristol and Cardiff. As already traditional, after each lecture the reunion has continued in a more informal and lighthearted way.

Other activities—A symposium on poliomyelitis took place with the collaboration of Dr W. Ritchie Russell, Mr D. M. Brooks, Dr A. B. Kinnier Wilson, Dr J. B. M. Davies and Mr G. P. Mitchell. A week-end course on the management of poliomyelitis for senior nurses of the Oxford Region was organised in this Centre with the collaboration of Dr J. F. Warin, Dr V. Smallpeice, Dr A. B. Kinnier Wilson and several members of the medical and nursing staffs.

The early morning clinical Conferences on Thursdays and Saturdays have continued to be well attended.

SCIENTIFIC SOCIETIES AND REGIONAL ORTHOPAEDIC CLUBS

THE BONE AND TOOTH SOCIETY

The Bone and Tooth Society held a Symposium on *Hereditary Skeletal Disease* at The Institute of Orthopaedics, London, on March 22, 1954. Dr H. A. Sissons was in the chair.

The genetics of human skeletal abnormalities—*Professor L. S. Penrose* considered that anomalies of skeletal morphology, many of them familial, were among the most striking of human variations. Some, for instance brachydactyly and ectrodactyly, could be explained by single gene action. More often, however, there was no simple explanation. There were many sporadic cases, and these had been attributed to fresh mutations, as in dyschondroplasia. Recessive skeletal defects could be identified most easily by noting parental consanguinity, as, for example, in

Morquio's disease. In some conditions it was difficult to distinguish the effects of heredity from those of pre-natal or even post-natal environment. This was especially true of common abnormalities, such as spina bifida, talipes, dislocation of the hip, hallux valgus, and others. Attention to occasional striking pedigrees in these, as in other diseases, might lead to an erroneous belief in the simplicity and homogeneity of genetical causes.

The development of a generalised skeletal anomaly—*Dr H. Grüneberg* recalled that the recessive gene for congenital hydrocephalus in the mouse was lethal at birth. The hydrocephalus (which was indirectly responsible for failure of the flat skull bones and various anomalies of eyelids and sensory hairs in the face) was caused mechanically by the growth of the brain in the confined space of an anomalous chondrocranium. This anomaly involved the cartilaginous skeleton as a whole, including the larynx. Most of the cartilages were reduced in size from the beginning, and in some places cartilage failed to develop altogether (though the " missing " parts might be represented by fibrous tissue). In some places there were anomalous fusions between neighbouring cartilages. Histologically, the cartilage was somewhat retarded at first, but became perfectly normal in the end. The basic anomaly was one of the mesenchyme. No matter whether a mesenchymal condensation was formed early or late in development, it was smaller than normal. The skeletal elements were thus smaller from the start, and as cartilage growth was normal, this initial disparity remained about the same. In some places the reduction in size of the mesenchymal condensations seemed to fall below some threshold below which chondrification could not take place. The cartilage fusions were presumably secondary effects.

The genetics of rickets and osteomalacia—*Dr H. Harris* said that the widespread use of Vitamin D to prevent and cure rickets and osteomalacia had revealed patients who, while showing the characteristic bone changes of these conditions, failed to respond to Vitamin D in the usual doses, but could be treated with enormously increased doses. This syndrome of " resistant rickets " was heterogeneous, and a number of genetically and biochemically distinct conditions could be recognised. In the commonest type, in which the only distinctive biochemical finding was a low serum phosphate, the affected individuals appeared to be heterozygous for a rare " dominant " gene. In another group hypophosphataemia was accompanied by gross generalised amino-aciduria, renal glycosuria and chronic acidosis. There was often a widespread deposition of cystine crystals in the body tissues (Fanconi syndrome, Lignac's disease, cystine storage disease, etc.). It was usually found in children and appeared to be inherited as a recessive mendelian character. The heterozygotes could not be identified. A similar condition, without cystic deposition, presented in adults as an osteomalacia, and was probably also a mendelian recessive. It had been found possible on occasion to identify predisposed individuals, and to anticipate bone changes by treatment.

EAST ANGLIAN ORTHOPAEDIC CLUB

A meeting of the East Anglian Orthopaedic Club was held at the Royal Air Force Hospital, Ely, on January 30, 1954. Clinical cases were demonstrated.

Sliding bone grafts—*Squadron Leader K. de Belder* gave a review of sliding bone grafts which had been carried out for delayed or malunion of the tibia and which produced bony union in all but one case. One case was associated with a circulatory calamity and one with sepsis, but despite these complications he felt that this was a valuable method of treatment and demonstrated four recent cases showing different stages of recovery.

Preservation of bone and arterial grafts—*Group Captain Mackenzie Crooks* discussed the preservation of bone and arterial grafts by the Walter Reed Freeze-Drying method. So long as vacuum was maintained in the container no special method of storing was needed. Experimentally in dogs the grafts were found to heal a little more slowly that autogenous grafts, but to be more resistant to sepsis. He also described the use of plastic tubes of " Oxlon " which made excellent arterial grafts in adults, and of plastic caps over kidneys, used experimentally in rats for hypertension and for plastic valves for aortic incompetence.

Miscellaneous cases—*Flight-Lieutenant K. Bryant* showed a number of cases, including a case of multiple fractures involving right femur, right tibia and fibula and left tibia, treated by Küntscher nailing and plating; and cases of staphylococcal osteomyelitis of the spine, and osteochondritis of the patella and femoral head. *Flight-Lieutenant L. Corbet* showed a case of multiple injuries—a head injury leading to traumatic epilepsy, a compound fracture-dislocation of the right ankle, a compound fracture of the right radius and ulna with non-union, and a fracture of clavicle. The suggested treatment was sequestrectomy in the arm and arthrodesis of the ankle. He also showed a case of congenital abnormality of the lower end of the ulna. Since a fall five years ago, some pain had

been complained of along the ulnar border of the hand. After some discussion it was agreed that the condition was best left alone. *Squadron Leader K. de Belder* showed the case of a boy with a spastic flat foot with a calcaneo-navicular bridge. *Flight-Lieutenant Bryant* spoke of the difficulty of making small splints to hold certain lesions adequately with plaster, and demonstrated with the help of Sergeant Hall the use of Tensol cement, with which tough, light splints could be moulded to any shape.

Films—*Wing-Commander D. M. Keir* illustrated by films a successful case of H-graft for lumbo-sacral fusion. Another film, introduced by *Wing-Commander P. H. Blackiston*, showed the use of a cuirass respirator for the air transport of patients nursed in a Drinker respirator, thus making their transport easier and much less extravagant of aircraft space.

BELGIUM

BELGIAN ORTHOPAEDIC SOCIETY

Officers for 1954—The following are the officers of the Belgian Orthopaedic Society for 1954: president, Dr H. Bonet (Liége); vice-presidents, Drs R. Soeur (Brussels) and B. Blankoff (Brussels); secretaries, Drs F. A. Poncelet and M. Belenger (Brussels); treasurer, Dr E. De Doncker (Brussels).

Recent proceedings of the Society—The Society holds monthly meetings and publishes its papers and discussions in the *Acta Orthopaedica Belgica*. These reflect most of the activities of orthopaedic surgeons in Belgium. Amongst the many subjects treated during this academic year, one of them was introduced by *Dr E. De Doncker* and *Dr E. Van Der Elst* of Brussels and concerned fractures of the shaft of both bones of the leg. It was followed by much discussion which was summarised and concluded in June by *Professor J. Verbrugge* and *Dr M. Belenger*.

The Society organises a special meeting each year at which the annual report is presented. This year the meeting took place in Liége on March 20. The subject, " Prevention and treatment of post-traumatic stiffness and ankylosis of the elbow," was introduced by *R. Remy* (Brussels) who has made an extensive study of these problems. He discussed the methods employed to prevent stiffness and ankylosis at the time of reduction, during immobilisation and during the period of recuperation. He insisted particularly on the danger of forced manipulations, recalling the classical principles emphasised by Hugh Owen Thomas and Sir Reginald Watson-Jones. He also reviewed the methods of surgical treatment.

In the discussion which followed *Professor E. Sorrel* (Paris) described three main types of elbow fracture in children, each of them implying a particular danger. 1) Supracondylar fracture with its vascular and nervous complications. He did not favour operative reduction but said that if it was necessary it should be done through an anterior incision. 2) Fractures of the lateral condyle, in which the main difficulty lies in the reduction. 3) Fractures of the medial epicondyle where one often finds the fragment included in the joint. The nerve and the muscles are drawn into the joint together with the fragment. Operative removal of the fragment should be undertaken. *Professor J. Verbrugge* (Antwerp) supported an opposite point of view. He had operated upon fifty-five children with supracondylar fracture by nailing the epiphysis through the lateral condyle. He used the incision of Ollier passing between the muscles. No post-operative plaster of Paris immobilisation was necessary. He believed that immediate operation was the best safeguard against Volkmann's contracture, extra-osseous ossification and joint stiffness. He also advocated nailing of fractures of the condyles and believed it to be an easy and secure method. The head of the radius should not be removed in children but its excision was a good method for old displaced fractures in adults. Professor Verbrugge also discussed varus or valgus deformities resulting from poor treatment. In children antero-posterior displacement mattered little but lateral displacement caused impairment of function and ugly deformity. *Dr A. Treves* (Paris), among other things mentioned that it was easy to reduce fractures of the elbow in adults under local anaesthesia. He stressed the danger of massage in post-operative treatment of this type of fracture in children. *Dr E. De Doncker*, speaking for *M. Belenger* of Brussels, held that x-ray therapy was of great value in the treatment of traumatic ossification of the elbow. He insisted upon the importance of a well planned physical treatment for stiff elbows. *Dr R. Soeur* (Brussels) was pessimistic about the value of surgical treatment for post-traumatic stiffness and bony ankylosis. The problem was still unsolved. On the one hand, capsulectomy gave very uncertain results while on the other hand arthroplasty very often created an unstable joint.

INTERNATIONAL SOCIETIES

THIRD INTERNATIONAL POLIOMYELITIS CONFERENCE

The third international poliomyelitis conference of the International Poliomyelitis Congress will be held in Rome on September 6–10, 1954.

Officers of the conference—The honorary presidents are Dr Basil O'Connor (U.S.A.), Dr L. Ragoczy (Denmark), and Professor Luigi Spolverini (Italy). The general chairman is Professor Carlo Marino Zuco (Italy). The executive secretary is Dr Stanley E. Henwood (U.S.A.). The following are members of the scientific programme committee: John R. Paul (Chairman), Morris Fishbein, Professor Gino Frontali, Professor Mario Gozzano, Rustin McIntosh, Thomas M. Rivers, Hart E. Van Riper, and Professor Carlo Marino Zuco.

Provisional programme—*Monday, September* 6: Official opening; "Social Aspects of Poliomyelitis"; official delegate reports. *Tuesday, September* 7: "Acute medical care in poliomyelitis"; technical discussion (mechanical devices for respiratory aid); film on respiratory physiology. *Wednesday, September* 8: "Infection and immunity in poliomyelitis"; demonstrations at poliomyelitis institute at Aviccia; developments in tissue culture. *Thursday, September* 9: "Orthopaedics" (recent methods of orthopaedic surgery in the treatment of poliomyelitis); physical medicine and rehabilitation. *Friday, September* 10: "Trends in poliomyelitis"; poliomyelitis as a world problem; future prospects.

Participation—Provision has been made for three groups of participants: official delegates, active members, and associate members (introduced by active members). Invitations to present scientific papers have been issued through the International Poliomyelitis Congress by the scientific programme committee. Time will be allowed for general discussion of these papers. The official languages will be English, French, Spanish, German and Italian. Simultaneous interpretation into these languages will be arranged. Correspondence and enquiries should be addressed to the Secretariate of the Third International Poliomyelitis Conference, Via Lucullo 6, Rome. Telegraphic address: Inpolio, Rome.

INTERNATIONAL SOCIETY FOR THE WELFARE OF CRIPPLES

SIXTH WORLD CONGRESS

The Sixth World Congress of the International Society for the Welfare of Cripples will be held at The Hague, Netherlands, from September 13 to 17, 1954.

It is particularly requested by the Netherlands Committee that those who wish to attend the congress should register at the earliest possible date. Registrations for the congress from Britain will be made through the British Committee, International Society for the Welfare of Cripples, 34 Eccleston Square, London, S.W. 1. Preliminary programmes and application forms are available from that address. These forms include information about hotel accommodation (early application is desirable) and a list of social events and excursions.

Book Reviews

DISEASES OF MUSCLE. By Raymond D. Adams, M.A., M.D., Associate Clinical Professor of Neurology, Harvard Medical School, Chief of Neurological Service, Massachusetts General Hospital; D. Denny-Brown, M.D., D.Phil., F.R.C.P., James Jackson Putnam Professor of Neurology, Harvard Medical School, Director, Neurological Unit, and Neurologist-in-Chief, Boston City Hospital; and Carl M. Pearson, M.D., Former Resident in Pathology, Mallory Institute of Pathology, Boston City Hospital. $9\frac{1}{2} \times 7$ in. Pp. xv+556, with 189 figures and 1 colour plate. Index. 1953. London, Toronto, Melbourne, Sydney and Wellington: Cassell and Company Limited. Price £5, 18s. 6d.

Although much detailed information on the pathology of diseases of muscle has accumulated over the years, the subject is most inadequately presented in text-books of general pathology or of clinical subjects, and is consequently familiar only to the restricted circle of clinicians and laboratory workers who have a special interest in this field. Until now no comprehensive account has been available, and the present volume—whose aim, as stated in the preface, is " to aid the student of morphology to an understanding of the whole class of muscle diseases "—is therefore welcome as filling an important gap in medical literature. Indeed, the gap is filled with distinction, and the volume, which comes from the Neurological Unit of the Boston City Hospital and the Harvard Medical School, will clearly be a standard work of reference on the subject for many years. Its authors are to be congratulated on providing an admirable and up-to-date outline of muscle diseases, which will be of immediate interest, not only to histopathologists, but to physicians, neurologists, orthopaedic surgeons and all others concerned with the study of the locomotor system.

After an outline of the histology and embryology of muscle, its basic pathological reactions are outlined, detailed reference being made to experimental studies of response to injury, regeneration and the events following denervation. The final section of the book comprises a systematic account of the pathology of muscle and includes important chapters on " Muscular Dystrophies," " Traumatic and Circulatory Diseases," and " Spinal and Neural Muscular Atrophies." In every section there is a strong interplay of clinical knowledge, neurophysiology and experimental pathology, all of which are esssential for an understanding of the morphology of muscle diseases. The work embodies a careful and scholarly survey of the extremely scattered literature on muscle pathology, and provides a most useful bibliography of various aspects of the subject. There is a good index; many carefully chosen photomicrographs illustrate the text; the standard of production of the book is high. Apart from its value as a source of general information on the muscle diseases, the book is of considerable practical importance—to clinicians and pathologists alike—at a time when biopsy examination is playing an increasing part in the diagnosis of muscle diseases, particularly those involving denervation or dystrophy.—H. A. Sissons.

RESECTION-RECONSTRUCTION OF THE HIP. Arthroplasty with an Acrylic Prosthesis. By Jean Judet, Robert Judet, Jean Lagrange and Jean Dunoyer. Edited by K. I. Nissen. 9×7 in. Pp. xii +151, with 101 figures. 1954. Edinburgh and London: E. & S. Livingstone Ltd. Price 30s.

It is the usual fate of a new operation, or indeed of any new method of treatment, either to be rejected without trial or to be used unscientifically with all the short-sighted enthusiasm dictated by fashion and nurtured by inexperience. Ultimately a mounting total of failures or of disasters leads either to discarding the technique or, usually years later, to better assessment of its usefulness and limitations. If the new operation is one that can be performed easily even if badly, or that can be mutilated enough to make its performance easy, it can be almost certain of over-enthusiastic reception and of equally silly repudiation. Such was the fate, to mention only one example, of internal fixation of fractures. " O stormy peple! unsad, and ever untrewe! Ay undiscreet, and chaungynge as a vane." Chaucer might well have written the lines of us.

In one sense, it is a very great pity that this book did not appear in 1950, for that year saw the start of the " acrylic-rush " in British surgery. The few who went to Paris and saw the Judet brothers learned from them that resection-reconstruction of the hip is something quite different from simply " putting on a prosthesis." It is a precise operation, demanding careful selection of

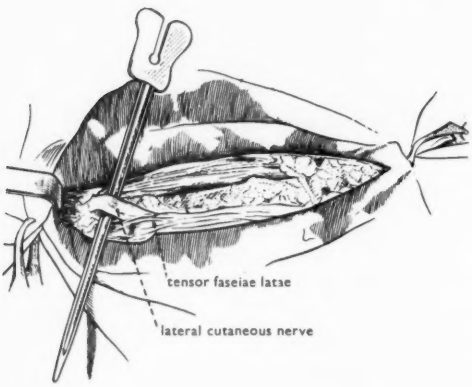


FIG. 9
The lateral cutaneous nerve is defined so that it may be carefully avoided during the operation and during closure of the wound.

patients, the proper instruments, properly made prostheses and adequate after-treatment; and, had this book appeared earlier, much trouble might have been saved. Instead, the people who applauded Robert Judet's modest presentation in Edinburgh in 1951 of his claims and his ideas were the same crowd who only two years later (" ay ful of clappyng ") cheered Capener's suggestion that the operation should be " grounded." The wheel had come full circle. Clogs to clogs in only two years.

This book brings us back to the spirit of 1951. Here are set out in careful detail " the technique, the pitfalls and the results " of the Judet brothers and of their team, with their stress upon the provisional nature of their conclusions and their careful insistence upon a really long study of the patients. The provisional nature of the whole thing is illustrated right at the start by the description of the new model of prosthesis which is being introduced to overcome some of the mechanical defects of the standard pattern. No exaggerated claims are made, and no complications are hidden or glossed over. The care given to the assessment of patients before operation is revealed in the method of clinical tabulation used (Chapter 1) and even in the fact that pre-operative studies of the coagulability of the blood are available in case it is desired to use anti-coagulants. The operation is reserved (page 17) for those patients whose disability is really intolerable, the authors advise remodelling of the acetabulum " in rather more than half the cases," and emphasis is laid upon an operative technique very different from the inexact methods used by many imitators.

A section of the book which will attract much attention is a series of twenty-one black and white photographs of the stages of the operation, each photograph being accompanied by an explanatory line drawing. This simple plan seems a very sound way of illustrating operative technique, but it is a pity that some of the photographs appear rather out of focus and not well lit. The applicability of the operation to a wide range of hip disorders is discussed, and a final chapter deals with tissue-tolerance of the acrylic material, the fixation of the prosthesis in bone, and similar factors.

The editor is to be congratulated. The translation into English is excellent. The first-rate quality of the volume is what we have come to expect from the publishers. The book is short and the price reasonable. No one should set out upon another acrylic arthroplasty without having read it.—D. Ll. GRIFFITHS.

OSTEOSKLEROSE UND KNOCHENMARKFIBROSE. By Rudolf STODTMEISTER, Dr med., Dr phil., apl. Professor für innere Medizin an der Universität Heidelberg; and Stefan SANDKÜHLER, Dr med., Assistant der Ludolf-Krehl-Klinik (Medizin. Univ.-Klinik) Heidelberg. Unter Röntgenologischer Mitarbeit by Albert LAUR, Dr med., Assistant der Röntgenabteilung der Ludolf-Krehl-Klinik (Medizin Univ.-Klinik) Heidelberg. 10×7 in. Pp. 135, with 29 figures. Index. 1953. Stuttgart: Georg Thieme Verlag. Price DM. 28.50.

This book is well produced with numerous excellent illustrations. The authors, who are physicians practising in Heidelberg, give an account of osteosclerosis and bone marrow fibrosis based on a very detailed clinical study of twenty-three cases. In general there is a discussion of each disease from the clinical and radiological angle and laboratory findings are clearly tabulated. A detailed anatomical and histological investigation has been made in most of the fatal cases and the authors' discussion of the various conditions is based on a comprehensive review of the literature.

Marble bone disease, sclerosis of the spongiosa (osteomyelosclerose), and bone marrow fibrosis (knochenmarkfibrose) are all generalised skeletal diseases. The first occurs in infants or young children, who usually present symmetrical club-shaped deformities of the tibial and femoral metaphyses at the knee. Transverse fractures, which heal normally, are common. Anaemia develops with marrow failure, and death is usually the result of failure of extramedullary haemopoiesis. Sclerosis of the spongiosa develops in adults, often under forty years of age, who present splenomegaly and radiological evidence of osteosclerosis. Anaemia develops much later, and these cases may run a course of fifteen years before death supervenes from failure of extramedullary haemopoiesis. Idiopathic marrow fibrosis occurs in older individuals, who present anaemia, sometimes with haemorrhage and loss of weight, and is considered by the authors to be entirely distinct from sclerosis of the spongiosa. The course is short and an intractable anaemia leads to death. Splenectomy in these conditions accelerates the fatal termination, as the authors emphasise.

Marble bone disease is shown to be a well defined syndrome due to disturbance of endochondral ossification, and one in which mechanical compression of the marrow plays a greater role than in other syndromes. Generalised periosteal hyperostosis arising in early childhood (Engelmann's disease) and the form developing at puberty or in adult life are considered together under the heading of hereditary periosteal hyperostoses. Toxic osteoscleroses are described in a separate chapter in which the effects of poisoning by phosphorus, lead, and fluorine are considered. In a short account of chronic hypertrophic pulmonary osteoarthropathy the etiology is not discussed.

Sclerosis of the spongiosa is discussed at length. The type with compensatory extramedullary haemopoiesis (Heuck 1879) is separated from the subacute febrile form without extramedullary haemopoiesis (v. Baumgarten 1899). It is shown that the degree of obliteration of the marrow spaces is insufficient to account for the severity of the clinically observed anaemia.

Bone marrow fibrosis is ascribed largely to a disturbance of capillary permeability in the haemopoietic marrow. This is thought to cause the accumulation of a serous exudate in the marrow spaces, which in turn interferes with the migration of mature marrow cells into the peripheral circulation and also produces the characteristic fibrosis. It is emphasised that there are few clinical and anatomical observations to suggest that the type of sclerosis of the spongiosa described by Heuck is really the end stage of bone marrow fibrosis. The authors point out that in an assessment of blood formation in cases of sclerosis of the spongiosa it is difficult to gauge the relationship between the activity of functioning marrow remnants and extraosseous haemopoietic foci.

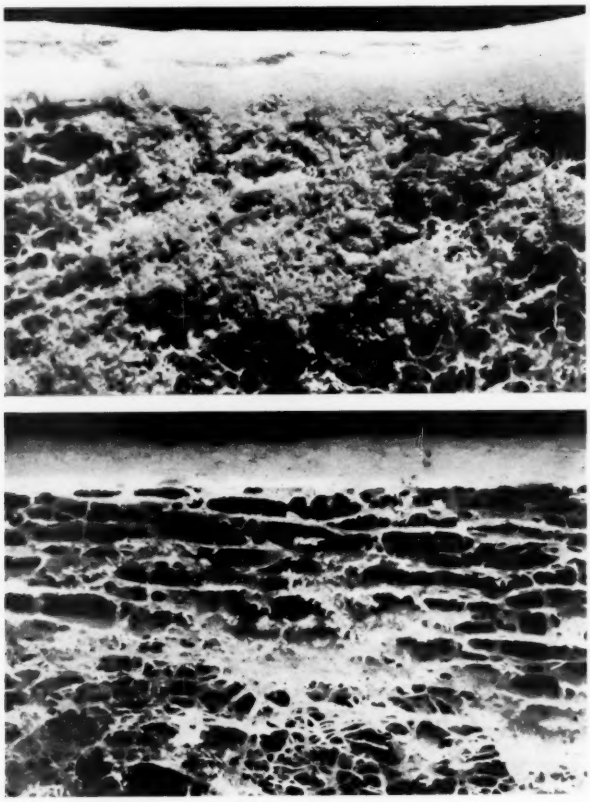


FIG. 10A

Sclerosis of the spongiosa. Photograph of femoral shaft under low magnification showing irregular deposition of newly formed bone in the original spongiosa.

In the final chapter on radiological differential diagnosis the authors point out that marble bone disease, osteopoikilosis, and melorheostosis were actually discovered radiologically. Bone marrow fibrosis can be diagnosed radiologically only in the late stages, and only in some cases. The authors stress the importance of the detection of truly osteolytic foci in the often difficult distinction of osteoplastic secondary carcinoma from sclerosis of the spongiosa.—P. C. MEYER.

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HEUCK, G. (1879): Zwei Fälle von Leukämie mit eigenthümlichem Blut-resp. Knochenmarksbefund. Virchow's Archiv für pathologische Anatomie, **78,** 475.

PELVO-SPONDYLITIS OSSIFICANS IN THE MALE AND GENITO-URINARY INFECTION. By Ragnar Romanus of the Department of Surgery, Karolinska Sjukhuset, Stockholm, and King Gustaf V's Research Institute, Stockholm. 9½ × 7 in. Pp. 368, with 7 figures. 1953. Stockholm: Acta Medica Scandinavica. Supplement 280. Price Sw. Kr. 40.

The author regards pelvo-spondylitis as a disease *sui generis* whose evolution is uniform and may be concurrent in different sites; these he lists as: *a*) pelvic (sacro-iliac joints, ischial tuberosity, rami and crista, tip of the trochanter, and symphysis pubis); *b*) spinal (intervertebral bodies and discs); and *c*) elsewhere (sternal and clavicular joints, and calcaneum). In all these sites he distinguishes two phases of the disease: *a*) the initial destructive phase with inflammatory osteoporosis, bone resorption and destruction, and possibly reactive sclerosis in adjacent tissues; and *b*) a secondary reparative phase, with proliferation, ossification and reconstruction.

In his experience the age of onset is usually between twenty and twenty-five, and 90 per cent of patients are male. The different distribution in the two sexes is said to be due to differences in the incidence and localisation of chronic foci of infection in the pelvis and the arrangements of the lymphatic and venous drainage; oestrogen production is considered to be protective. Definite familial incidence was demonstrated in six patients in the author's series.

A causal relationship between urogenital infection and pelvo-spondylitis is suggested in ninety-seven out of 111 males; twenty-six of these had gonorrhoea. Chronic ulcerative colitis was thought to be related to the disease in three patients. Definite pathological findings were made in twenty-five cases, twenty of which were due to staphylococcal infection. This was based on cultures of the prostatic and vesicle secretion and of the urine. In ten cases the anti-staphylolysin titre was raised concurrently. Anti-staphylolysin titrations was carried out in 108 patients, thirty-nine of whom had values below 1·4 which was regarded as normal. The author implies that titres above 1·4, which he found in sixty-nine patients, were pathological, and in one case (98) he says, " The anti-staphylolysin titre was 1·6 but became normal as the staphylococcus aureus disappeared from the secretion." The reviewer does not regard any fluctuation below 2 units as significant. The author emphasises that the infection is not specific in nature, and the organisms listed comprise the gonococcus, the staphylococcus, the streptococcus, certain coli forms, and the agent of Reiter's syndrome.

Twenty biopsy specimens were examined from different regions of sixteen patients and their histology showed essentially similar inflammatory changes, irrespective of their localisation to joints, discs, or paravertebral connective tissue.

Many reasons are given for not regarding pelvo-spondylitis ossificans as merely rheumatoid arthritis of the spine. The clinical differences are well known but, in addition, the author points out that in his series only four out of ninety patients had raised titres in the sheep cell agglutination test (Rose's Test) whereas in rheumatoid arthritis 80 per cent were positive. Another difference is in the serum protein spectrum. The onset of pelvo-spondylitis should be dated from the first peripheral attack, until it has been proved that this is of another nature. Among the peripheral symptoms the author includes iritis which occurred in thirty-three of his 117 cases and was the initial lesion in seven. The E.S.R. in general follows the course of the pelvo-spondylitis activity though it may be normal during active disease.

Many patients were treated with short courses of blood transfusion, antibiotics, and chemotherapy; all were given x-ray therapy. The chronic urogenital infection was treated with free drainage by expression and massage, when necessary supplemented by dilatation of the urethra, catheterisation of the ejaculatory ducts and sometimes irrigation from these or from the vas. The author claims that in every case in which this latter comprehensive treatment was given " its effect was striking, not only on the urogenital symptoms but also on the general condition of the patient, the E.S.R., the general rheumatic symptoms and on the pelvo-spondylitis symptoms."

This is an important study though its compilation suggests that the author is an overworked clinician. It lacks order and conciseness and has no index. The literature on various aspects of this syndrome is surveyed in different sections and there is a bibliography of about 450 references.

The marked decrease in gonorrhoea in Great Britain has probably led many orthopaedic surgeons to ignore the urogenital tract as the source of the infection responsible for obscure arthritic conditions. It is worth bearing in mind that in England and Wales in 1951 there were reported 10,794 cases of non-specific urethritis compared with 14,973 of gonorrhoea in the male. Most orthopaedic out-patient departments are too public for the Kinsey type of interrogation which this author advocates, and he is probably justified in saying to those who deny this high correlation between urogenital infection and ankylosing spondylitis that they have never asked the relevant questions in the right way.—Charles H. Lack.

SYNOVIAL FLUID CHANGES IN JOINT DISEASE. By Marian W. Ropes, M.D., Associate Physician Massachusetts General Hospital, Assistant Clinical Professor of Medicine, Harvard Medical School; and Walter Bauer, M.D., Chief of Medical Services Massachusetts General Hospital, Director of Robert W. Lovett Memorial Foundation for the Study of Crippling Diseases. 9½×6 in. Pp. xvi+150, with 15 figures, 14 tables and 1 chart. Index. 1953. Published for the Commonwealth Fund. Cambridge, Massachusetts: Harvard University Press. London: Oxford University Press. Price 25s.

This monograph is based on twenty years' study of the synovial fluid from large numbers of patients with disease of the joints: but it is not based on this alone. The Lovett Fund Group under Walter Bauer's far-seeing direction and enthusiasm have also studied closely the physiological, biochemical and pathological aspects of joints in health and in disease: they have followed their patients carefully and long, so that the correlations they establish between the characteristics of any particular group of fluids and the underlying disease process have an authoritarian basis without equal in this field.

Data obtained relate to pressure, pH, specific gravity and volume of the effusion, and to its content of organisms and antibodies, of lymphocytes and erythrocytes, of protein, fibrinogen, mucin (including viscosity, which is largely determined by the mucin), uric acid, bilirubin, sugar, lactate, electrolytes, lipids and enzymes. Details of these findings are given in fifteen diagrams and fourteen tables, and in one folding chart tucked inside the back cover which gives at a glance, for each pathological condition, the lowest, mean and greatest value of each constitutent, together with the number of such joint fluids examined.

A detailed discussion of each of these constituents, its correlation with other constituents and the factors governing its variation in health and disease leads logically then to a division of diseases into two main groups with a third intermediate one. In the first group, diseases of traumatic origin, the synovial fluid has little protein, few polymorphs, a sugar concentration approximating to that of the blood, and a high viscosity; the mucin clot precipitated by acetic acid is ropy. In the second main group of diseases, including rheumatoid arthritis and infective arthritis, the fluid has much protein, many polymorphs, little sugar, and a low viscosity; mucin is poorly precipitated. The third group includes such entities as gout, rheumatic fever, scurvy, acute lupus erythematosus, erythema nodosum and others: the synovial fluid is of an intermediate character. Each disease is dealt with separately. Finally, a section summarises the diagnostic value of joint aspiration and gives several examples.

A bibliography is appended of 220 references, of which only four refer to "unpublished data." The book is very well produced, as one comes to expect of Commonwealth Fund publications. It is an essential possession of any serious student of joint disease and of great interest to many other workers in clinical medicine, physiology and biochemistry.—E. G. L. Bywaters.

PRINCIPLES OF VERTEBRAL TOMOGRAPHY. By Ingemar Bokstrom. 10×7½ in. Pp. 126, with 67 figures. 1953. Stockholm: Acta Radiologica. Supplement 103. Price Sw. Kr. 20.

Tomography of the skeletal system is now an accepted procedure in orthopaedic radiology. In this work a description is given of many experiments designed to assess the advantages and limitations of the method when applied to the spinal column. The results of the experiments have been correlated with complementary clinical material. Most of the conclusions coincide with expectation.

Experimental defects of 3 millimetres depth in the cortex and of 8 millimetres diameter in the spongiosa, which are invisible or poorly defined in the plain film, become clearly delineated in the tomogram. Central defects were filled with water rather than air or paraffin wax in order to produce the greatest similarity to tumour tissue. The radiotranslucency of paraffin wax is comparable to that of fat, so that its use does not allow a true comparison with a clinical case. The customary tomographic method is performed in the long axis of the spine. Although the anterior border of the vertebral body can be more successfully defined, with an anatomical specimen, by using a transverse axis, this advantage is in practice vitiated by secondary radiation. Circumscribed osteolytic lesions and small fractures, particularly those associated with metastatic deposits and myelomatosis, can be revealed with much greater accuracy in a tomogram than in a standard film. The author comments on the fact that in suitable cases, in which the lateral tomogram is more informative than the plain film, even more advantage is gained from an antero-posterior tomogram in comparison with the plain antero-posterior view. The method has no advantage in demonstrating the detail of the spongiosa, and is consequently of less value than the

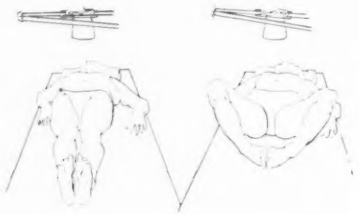
standard film in the examination of diffuse lesions. Its efficiency is also impaired when a central osteolytic lesion is surrounded by the decalcified bone of senile osteoporosis. Osteoplastic deposits are readily demonstrated in the plain film. A note of warning is sounded in connection with the radiation skin dosage—3r per exposure for the dorsal spine and 8r exposure for the lumbar spine. These are the first quantitative assessments of this nature. Rather surprisingly, no reference is made to the value of tomography in the oblique position, when it is useful in demonstrating the defects in the pars interarticularis associated with spondylolisthesis.

The whole work is painstaking in detail and provides the first comprehensive account of the basic principles of this method of diagnosis. It includes an extensive review of the literature and should prove a valuable acquisition to the bibliography of this subject.—Ronald O. Murray.

SLIPPED CAPITAL FEMORAL EPIPHYSIS. By Armin Klein, Robert J. Joplin, John A. Reidy and Joseph Hanelin, Massachusetts General Hospital, Boston. $10 \times 6\frac{3}{4}$ in. Pp. xiv + 130, with 77 figures. No. 153, American Lecture Series. 1953. Oxford: Blackwell Scientific Publications Ltd. Springfield: Charles C. Thomas. Toronto: The Ryerson Press.

Based on twenty years' work, this is a straightforward and detailed account of the diagnosis and treatment of slipped capital epiphysis of the femur, with emphasis on radiology and nailing. Important displacement is corrected by the open method, except in those cases of sudden

POSITIONING FOR BILATERAL HIP ROENTGENOGRAPHY



ANTEROPOSTERIOR LATERAL

Both hips are included on a 14 x 17 inch film placed transversely.

The tube is centered above the midpoint of a line connecting the acetabula.

Fig. 1

(Two-thirds of actual size.)

slipping that allow *gentle* manual reduction. The book contains an atlas of radiographs of normal hips in childhood and adolescence, taken in the simple standard manner shown in Figure 1. Strict comparison between this material and similarly taken films in cases of epiphysial slipping revealed some slipping on the opposite side in no less than 40 per cent of cases, often without symptoms. The authors rightly emphasise the vigilance that both femoral heads deserve after the nailing of one. Fracture in three cases, where the cortex was pierced by the nail, has prompted its routine removal when the epiphysis has fused.—H. Jackson Burrows.

CHEMICAL PHYSIOLOGY OF CONTRACTION IN BODY AND HEART MUSCLE. By A. Szent-Gyorgyi, The Institute for Muscle Research, at the Marine Biological Laboratory, Woods Hole, Massachusetts. $9\frac{1}{2} \times 6\frac{1}{2}$ in. Pp. xx + 135, with 29 figures. 1953. New York: Academic Press Inc., Publishers. Price $4.80.

Few other physiological changes have been subjected to as much study and have been surrounded by as many theories as those biochemical processes accompanying muscular contraction. In this, his third book on the subject, Professor Szent-Gyorgyi adds further facts and theories to those already presented. Essentially the book consists of a detailed account of the state of

knowledge based mainly on the work of the author and his colleagues. Where there are gaps, interesting speculations are presented of what he thinks the full picture may prove to be. Although the book does not set out to be a comprehensive and objective review, it would have been valuable to have learnt more fully why the author apparently discounts the important work of others who do not agree entirely with his own ideas.

The book can be roughly divided into three parts. The first part, "the Molecular Mechanism of Motion," is a detailed account of the basic mechanochemical changes that occur during contraction, changes which are mainly reactions of actomyosin, adenosine triphosphate and ions. The appreciation of these, the author maintains, is his laboratory's main contribution to the problem of muscular contraction, a contribution which was at first violently opposed, especially in England, but which is now, he believes, generally accepted as a basis. On this basis, an attempt is made to correlate these reactions to physiological observations, although many still cannot be so interpreted. The second part discusses observations on the contraction of the frog's heart and the rabbit's uterus and the effect of various drugs on these tissues. Included are some interesting comments on how these drugs exert their influence and on the application of some of the findings to therapeutics. For instance, he claims that the results of himself and his co-workers raise serious doubts as to the accuracy of the standardisation of digitalis preparations. The third part represents an effort to weave together into a coherent story the results reported in previous chapters. This concludes with a list of the actual events in the full cycle of contraction from those started by the arrival of the nerve impulse. Such an inventory, he suggests, "helps not only biochemical research but offers a solid basis for the analysis of pathological conditions."

It is difficult to decide for whom the book was written. Although the author sets out to write in a language understandable to the average biologist and to stress outline more than detail, many people, apart from those with an intimate knowledge of the field, may find it difficult to digest. Even the "Prefatory Note on the Histology and Physiology of Muscle" intended for those not acquainted with its structure and function may dissuade the most ardent reader from venturing further. However, one may be spurred on by Professor Szent-Gyorgyi's obvious desire that the results of his work should be of practical use and by his beliefs that "the attractions for the medically minded investigator will be spiced by the knowledge that dysfunction of muscle is death's main caterer" and that it will eventually be possible "to translate our theoretical knowledge into a reduction of human suffering."—Howard D. Darcus.

STRAPPING AND BANDAGING FOR FOOTBALL INJURIES. By John H. C. Colson, Fellow of the Chartered Society of Physiotherapy, Member of the Society of Remedial Gymnasts, and the Association of Occupational Therapists. Foreword by William Gissane, M.Ch., F.R.C.S. $10 \times 7\frac{1}{2}$ in. Pp. ix + 85, with 180 figures. Index. 1953. London: Published officially for The Football Association by The Naldrett Press. Price 10s. 6d.

For those of us who were once actively interested in sport and vaguely medical, and those of us who are medical and still vaguely interested in sport, this book—at any rate as far as legs are concerned—is the long awaited answer to a prayer. What doctor, who has ever watched a game of any sort, has not been intrigued—and, yes, perhaps a little annoyed—with the uncanny witchcraft of the trainer, the coach, the "rubber," which enables him to deal so rapidly, efficiently and confidently with those minor afflictions of sport that are so common and yet so conspicuously absent from the medical text-books. And now in this excellent book of Mr Colson's one finds that, out of the experience of years, the great Football Association at any rate has been dealing with these injuries on a practical, scientific and entirely well organised basis. The book, with its succinct 85 pages and its meticulously detailed 180 figures (by S. Francis), tells a simple story, first of sound common sense, based on clear elementary and accurate anatomy, and obviously backed by thoroughly up-to-date orthopaedic advice. In the preliminary chapters, the materials required to carry out the treatment advocated, and the methods of achieving it, are clearly described in language intelligible to any layman—and any doctor! The author's thesis that recent injuries demand a judicious mixture of pressure bandaging and rest, followed by protected and graduated use of injured parts, helped by physiotherapy, is convincingly set out—and has proved itself in action. One only hopes its field will not be limited to its sponsors—The Football Association—as it would have the greatest value in many other spheres of sport; and also that it may be but the precursor of others on the arm and the trunk.—Arthur Porritt.

AKUTE HANDCHIRURGIE. By Erik MOBERG, Leiter der Handchirurgischen Abteilung der Chirurgischen Universitätsklinik I in Göteborg. 8 × 5½ in. Pp. 54, with 25 figures. 1953. Lund: CWK Gleerup Bokförlag. Soft cover. Price Sw. Kr. 5.75.

Dr Moberg is well known for his work on surgery of the hand. This pocket volume is a concise expression of his views based upon practical experience and is in line with modern thought. There

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FIG. 11
(One-half of actual size.)

are two main sections. The first is concerned with anaesthesia, general technique, wound dressing and splintage. The second deals briefly with infection and in more detail with bone and joint injuries. There is something for all to glean from this little book, and it is to be hoped that the author will consider its publication in the English language.—R. G. PULVERTAFT.

THE NATIONAL HOSPITAL, QUEEN SQUARE (1860–1948). By Sir Gordon HOLMES, M.D., F.R.S. 10 × 7 in. Pp. xii + 98, with 8 plates. Index. 1954. Edinburgh and London: E. & S. Livingstone Ltd. Price 10s. 6d.

It is difficult to realise that this hospital known far and wide as " Queen Square " was founded less than one hundred years ago, so great is its renown. Many will want to read its history. This book will be welcome were it only for bringing to mind the name of a courageous woman—Johanna Chandler—who founded the hospital to treat epileptics elsewhere than in lunatic asylums. She and her sister raised money by making and selling shell and glass beads; and when £800 was in hand building was begun. It was a private enterprise, no longer possible under a State Medical Service. The hospital must early have won a name for itself, for it was able from the beginning to get house officers for nothing. We learn also that the physicians, the giants of their day, were at one time at the beck and call of a lay secretary-director who admitted what patients he liked and discharged them at his leisure irrespective of the wishes of the medical staff. This book recalls the names of the famous men associated with Queen Square, and is written by one who is not unworthy to take his place beside them.—George PERKINS.

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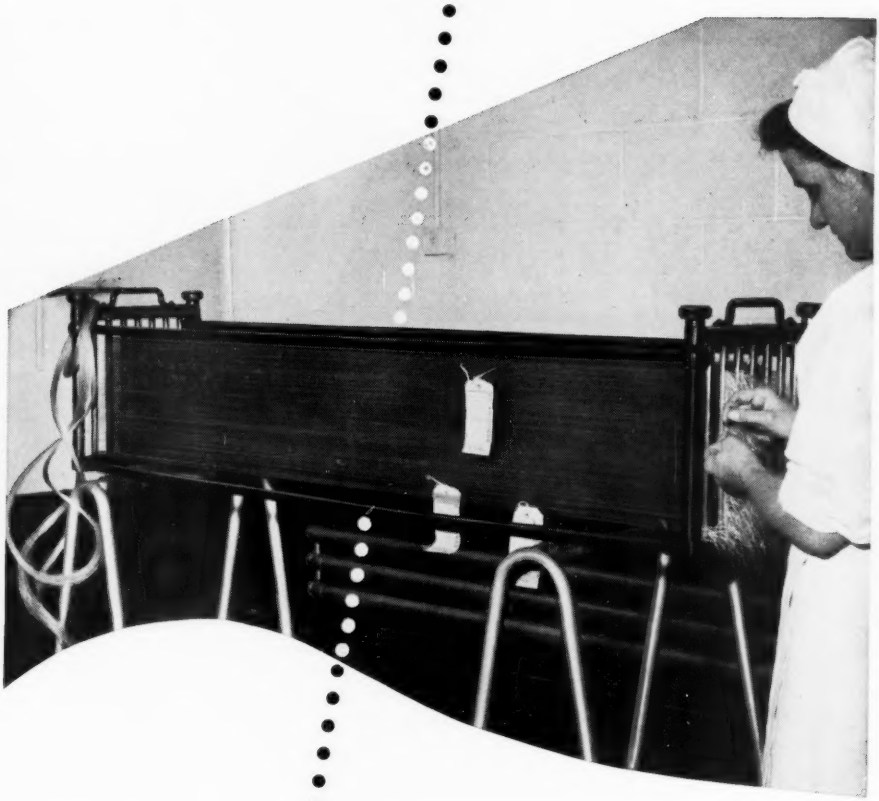

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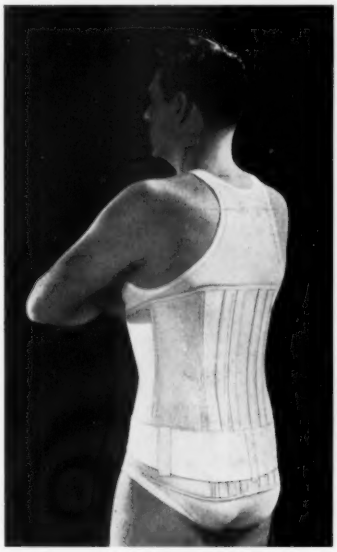

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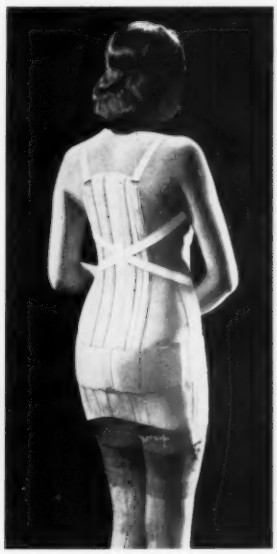

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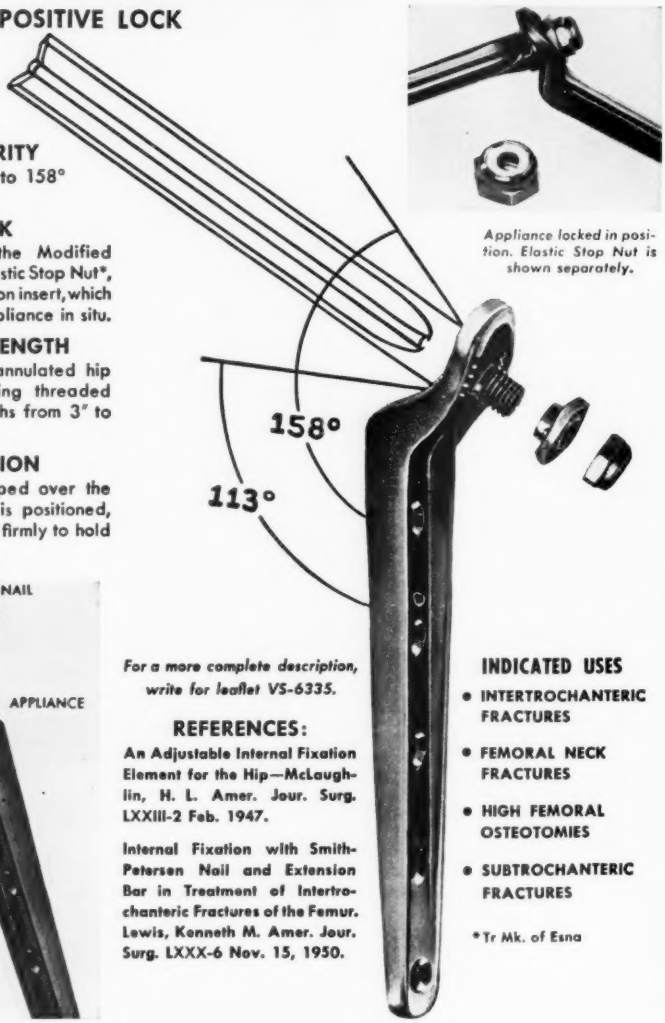

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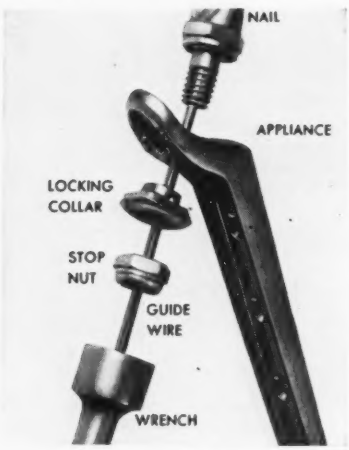

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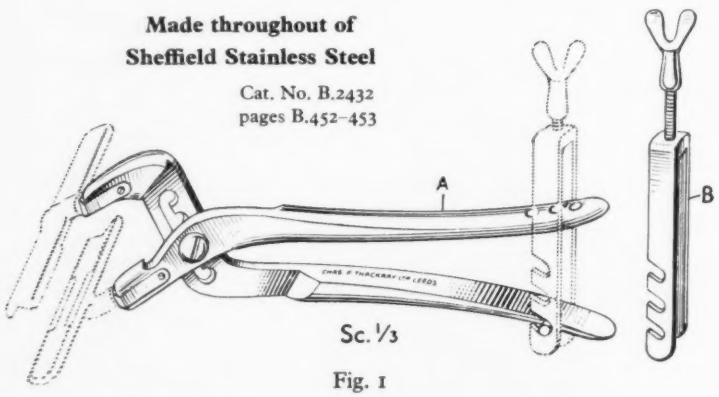

Fig. 1

The relative directions of jaws and handles—almost a right angle—make for easier manipulation of drills, etc. The jaw opening is controlled by a sliding hinge which enables the forceps to be adjusted to various widths. The forceps are locked by the handle clamping device.

* *Vide "Journal of Bone and Joint Surgery," pages 288 and 289, British Number—May 1953, Vol. 35-B, No. 2*

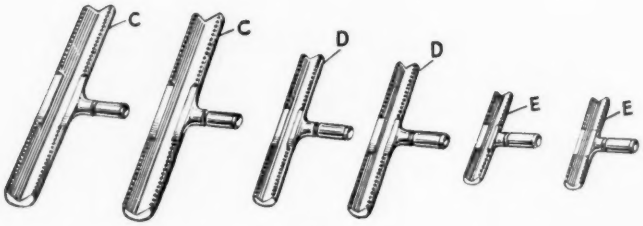

Fig. 2

The essential feature is the shape of the detachable jaws. Made in three sizes, they are V-shaped in section with serrated edges, the fractured long bone being gripped by parallel channels which automatically coax the fractured parts into alignment. The smallest pair is used for the radius and ulna and the other two sizes for large bones, though it is surprising how often the small pair of jaws can be used.

The shanks are $\frac{1}{4}$" thick, short and solidly welded to the serrated jaws for maximum rigidity.

Fig. 3

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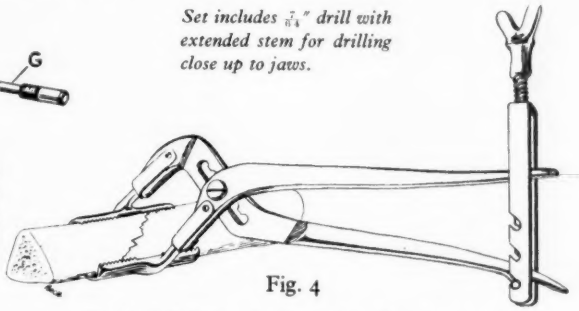

Fig. 4

The jaws swivel in the forceps so that pressure is evenly distributed and fragments which taper or are of different diameters are securely held.

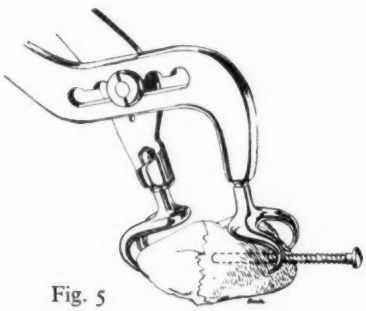

Fig. 5

Hooked jaws used to grip a fractured patella.

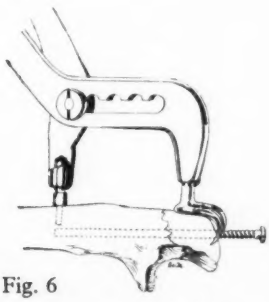

Fig. 6

Hooked jaw and peg used to grip fractured olecranon. A hole of $\frac{1}{8}$" diameter is drilled in the shaft of the ulna or tibia to act as a fixation point.

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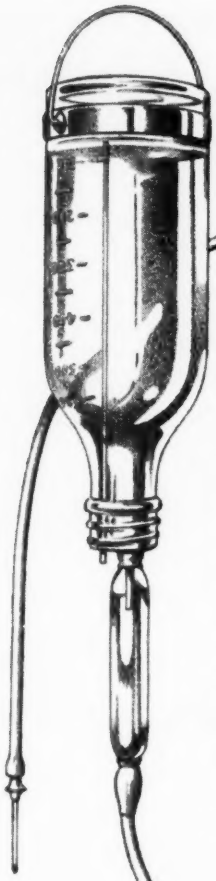

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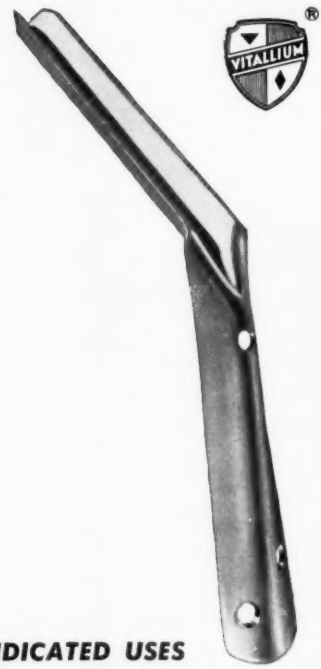

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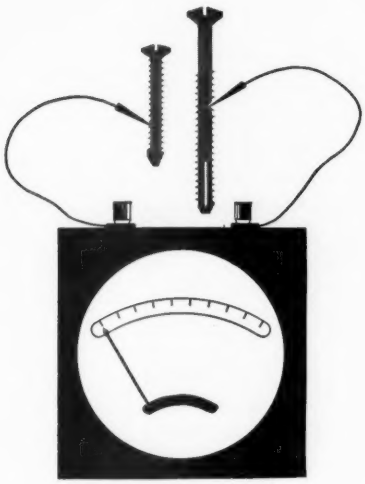

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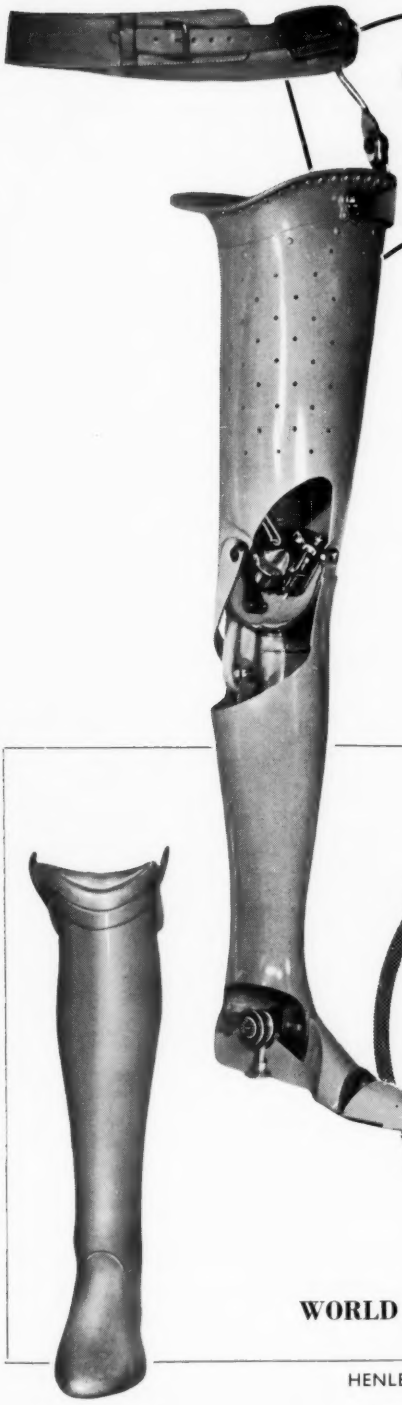

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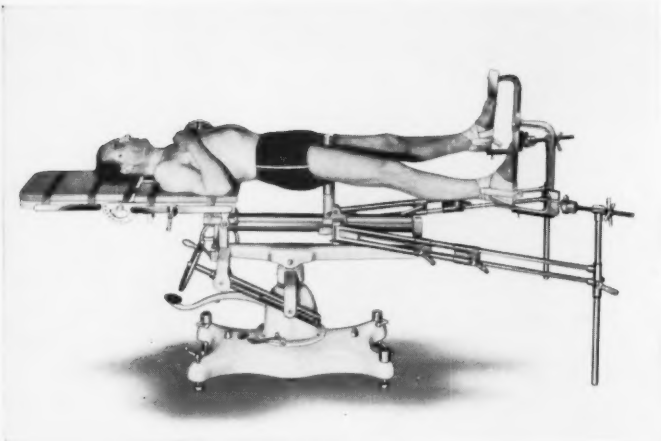

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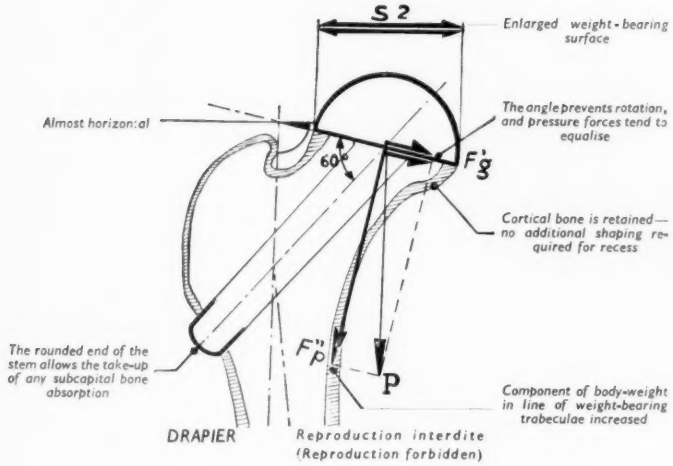
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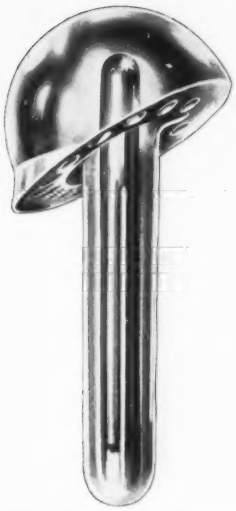

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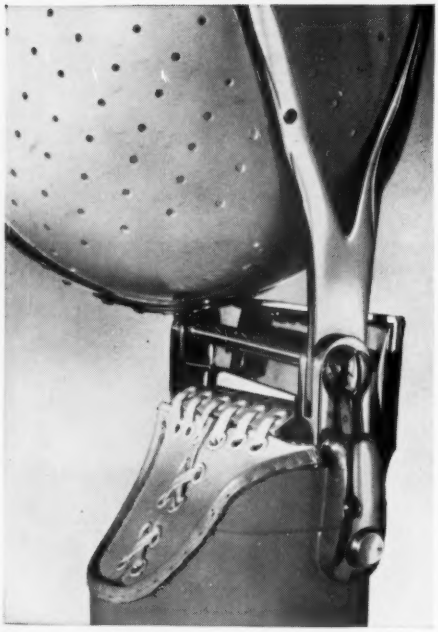

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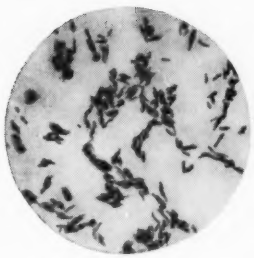

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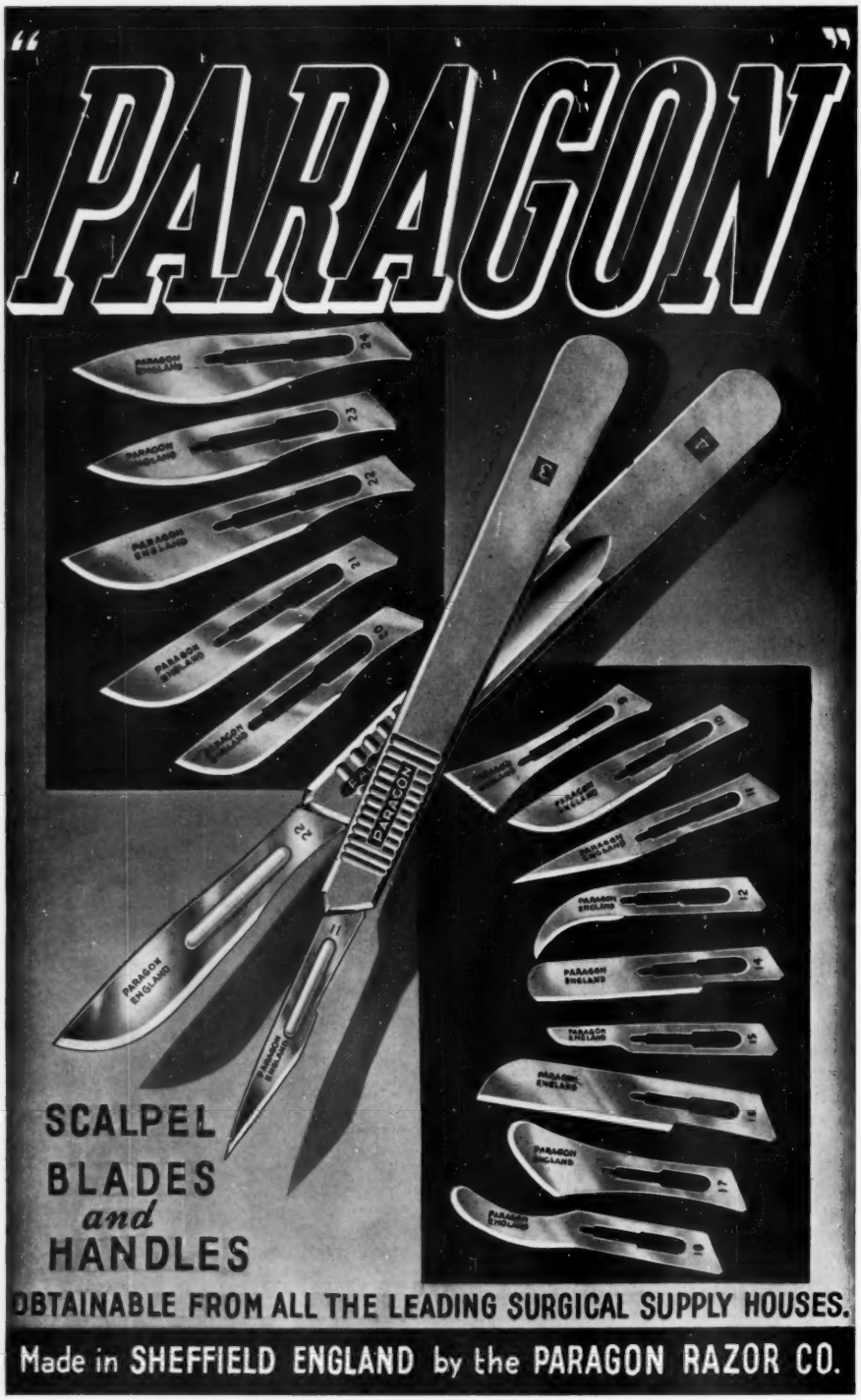
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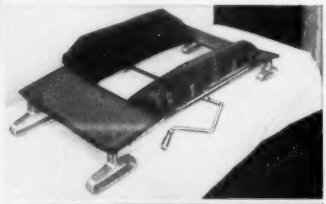

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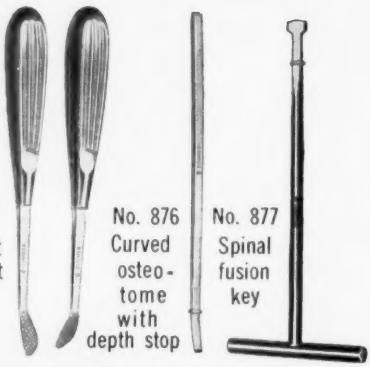

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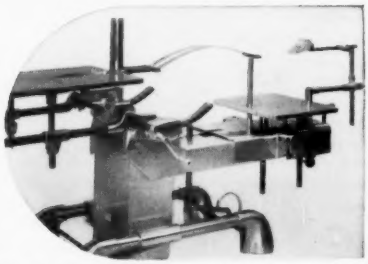

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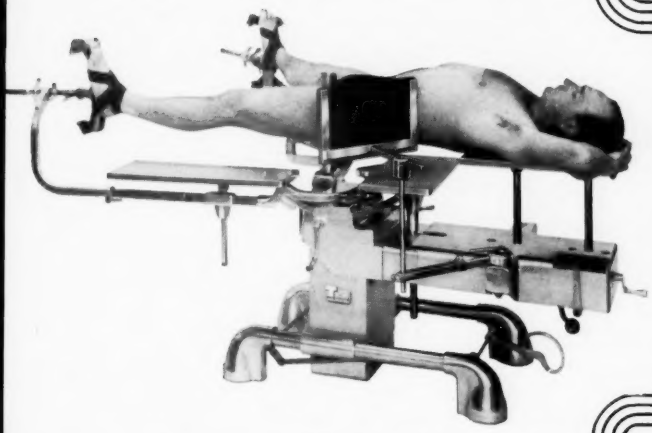

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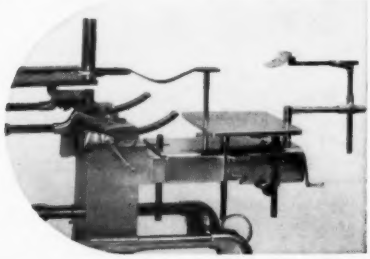

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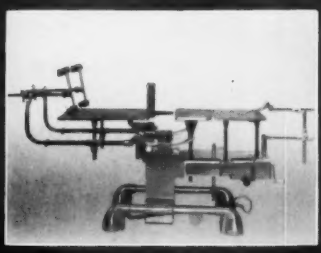

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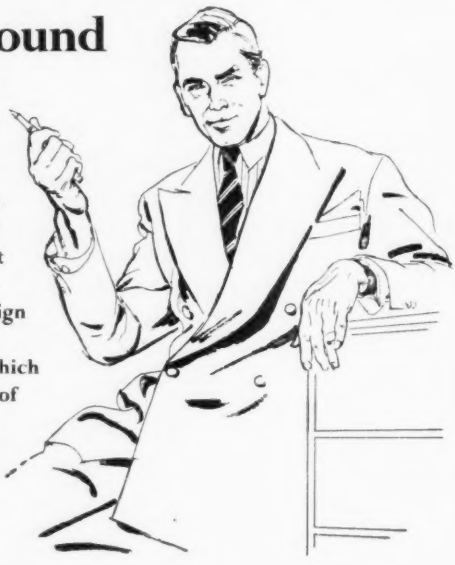

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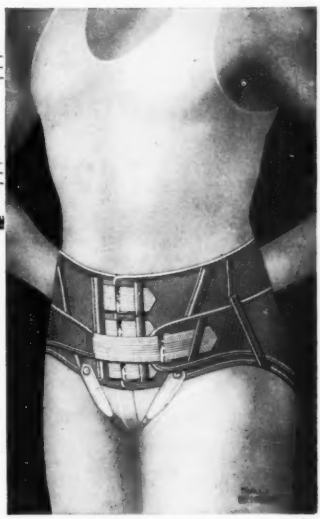

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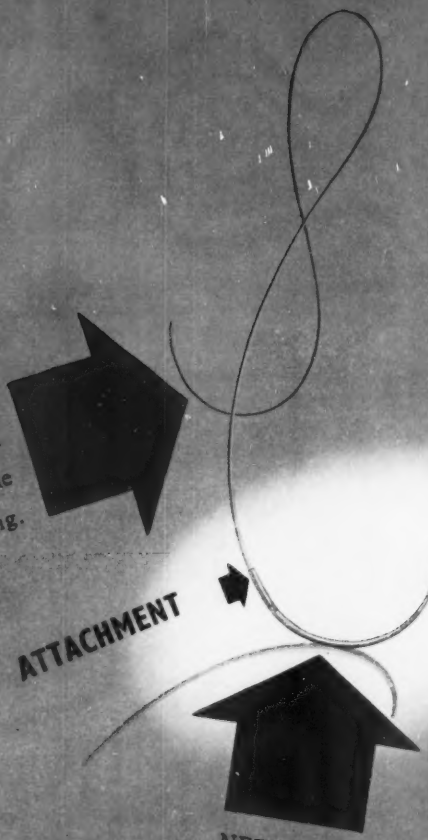

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